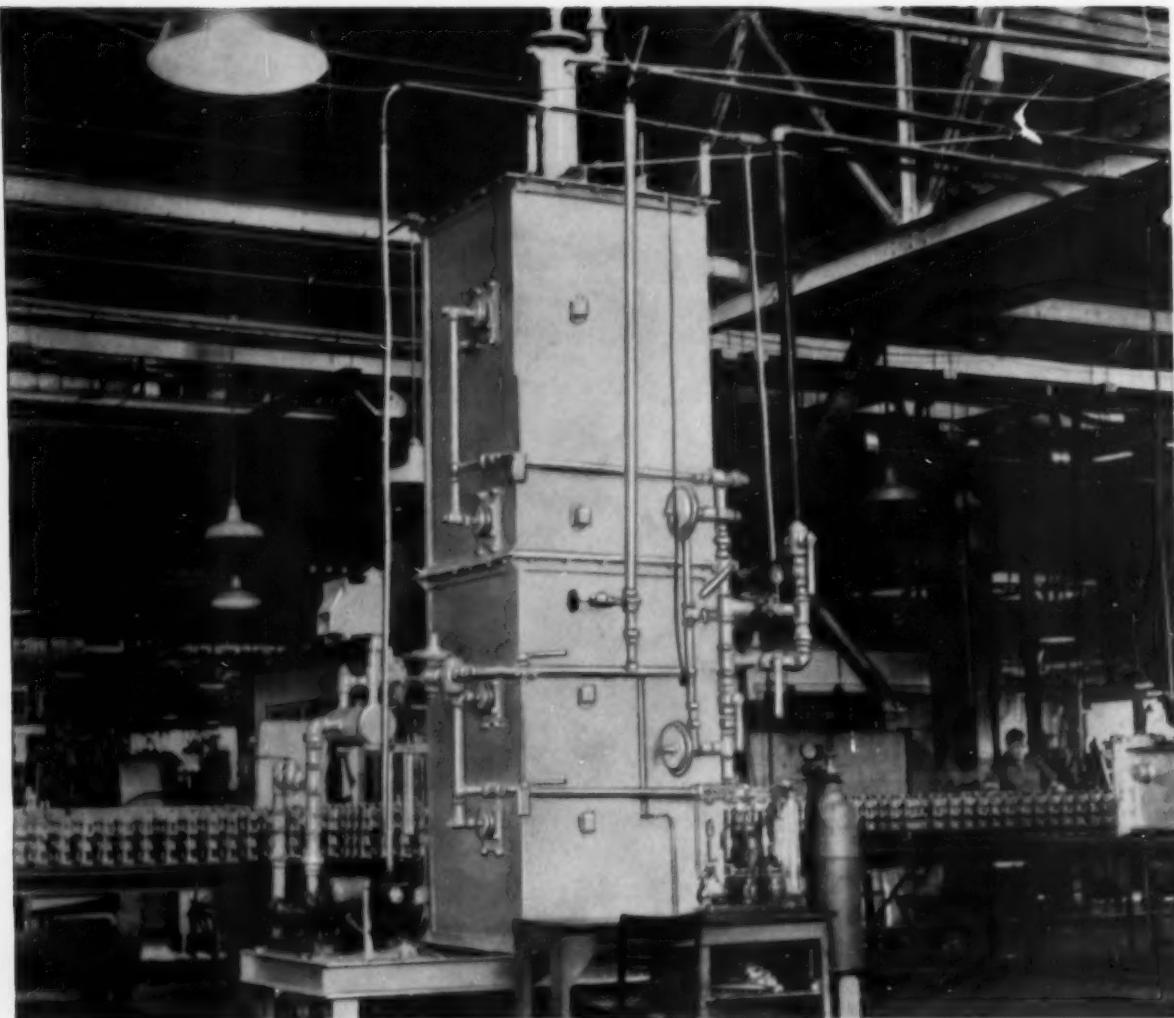


METAL PROGRESS



SEPTEMBER 1956



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Metal Progress

Volume 70, No. 3

September, 1956

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ERNEST E. THUM, *Editor*
FLOYD E. CRAIG, *Art Director*

MARJORIE R. HYSLOP
Managing Editor

HAROLD J. ROAST, E. C. WRIGHT and J. L. MCCLOUD
Consulting Editors

Cover by JOSE VAZQUEZ

National Metal Congress and Exposition

Invitation	65
Technical Programs.....	66

The Congress and the sessions of the cooperating societies give such a variety of technical fare that the complete programs are presented morning by morning and afternoon by afternoon so the metals engineer may efficiently plan his week's schedule.

National Metal Exposition	85
Exhibitors, booth numbers and brief descriptions of products.	

Engineering Articles

Economic Atomic Power Depends on Materials of Construction, by John H. Frye, Jr. and James L. Gregg	92
--	----

If metallurgists, ceramic engineers and chemists can produce the necessary constructional materials and low-cost uranium refining methods, a breeder reactor using uranium isotope 233 and a thorium blanket can generate heat at costs comparable to steam boilers using coal. (T25, U, Th, Al, Zr)*

Magnetite Concentrates to Supplement High-Grade Iron Ore, by E. C. Wright	97
---	----

As the high-grade Mesabi mines are being mined out, concentration of low-grade ore is coming ahead. One plant will make 3,500,000 tons of 63% iron pellets in 1956; another twice as large is under construction. (B13, B14, B16, Fe)

Materials in the Automobile of the Future, by A. L. Boegehold	103
---	-----

The future family car will be no smaller than present models; it will weigh less because of generous use of light metals. The spark ignition gasoline engine will persist, but will be more efficient and lighter, even if more powerful. (T21)

Forming Sheet Metal Components for Aircraft, by John F. Tyrrell.....	110
--	-----

Designs of aircraft change so rapidly that few sheet metal parts are ever produced in appreciable volume and some unique techniques have been developed to minimize retooling cost. (G general, SG-j)

Table of Contents Continued on P. 3

METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription \$7.50 a year in U.S. and Canada; foreign \$10.50. Single copies \$1.50; special issues \$3.00 . . . The A.S.M. is not responsible for statements or opinions in this publication.

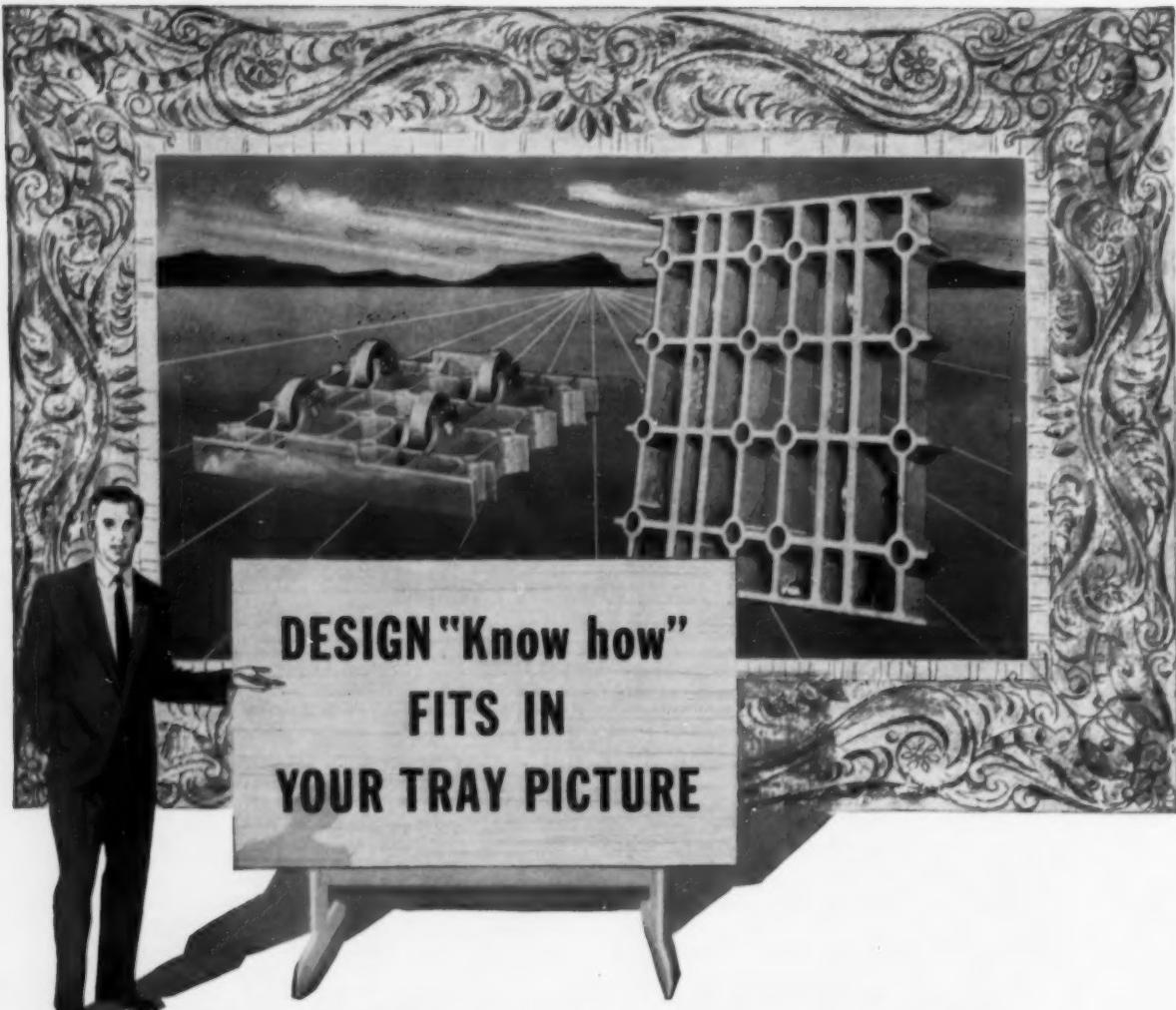


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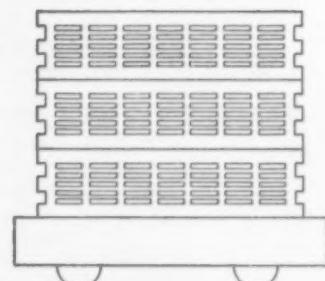
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Metal Progress

Contents Continued

Recent Developments in the Art of Precision Casting, by Nicholas J. Grant.....	113
Time-tested processes using disposable patterns (wax, plastic or mercury) must compete with others using a thin-walled mold in which the casting solidifies quickly to a fine grain. (E 15)	
Electric Versus Openhearth, by J. E. Wilbanks.....	118
Operating records in a cold metal shop having three 75-ton openhearts and two 75-ton electrics show that the latter can make steel faster and cheaper whenever scrap costs less than pig iron, and the product has equal or better quality. (D 2, D 5, ST)	
Metal Powder Rolling — a New Fabrication Technique, by Samuel Storchheim.....	120
Wartime work in Germany on driving bands for artillery shells has been extended in America to 18-8 stainless steel and other powder metal combinations for manufacturing fuel elements for atomic power reactors. (H 14, Fe, SS, Al)	
The Light Metals in American Economy, by Francis C. Frary.....	128
Did you know that only 10% of the aluminum made in the U.S. in 1955 went into aircraft, or that the largest single use of magnesium is as an alloying metal? Innumerable post-war applications have resulted from wartime experience. (T general, Al, Mg)	

Data Sheet

Power Reactor Programs in the U. S.....	96-B
A tabulation of the characteristics of 25 nuclear reactors in the U.S. supplements the article by Frye and Gregg on p. 92.	

Atomic Age

Radiation Damage to Unborn Generations.....	127
Six committees of eminent scientists have reported to the National Academy of Sciences their studies of the effect of high-energy gamma radiation on genetics, pathology, weather and food supplies.	

Correspondence

More on Aluminum-Silicon Pistons, by E. V. Dewhurst; W. C. Cheney.....	133
Metallurgists Wanted Badly, by A. J. Smith.....	133

Digests of Convention Papers

Fatigue Life of Aircraft Quality Verstus Vacuum Melted 4340.....	152
Temperability of Steels.....	152
New Nodular Iron Process.....	154
Toughness of Malleable at Low Temperature.....	158
Air Contamination of Titanium Alloys.....	160
Transformation on Continuous Cooling.....	172
Sigma in Cr-Co-Mo Alloys.....	174
Notch Toughness of Ingot Iron.....	178
Deformation in Iron Crystals.....	180
Tougher Iron-Aluminum Alloys.....	182
Advantages of Alpha Versus Beta Titanium at High Temperatures.....	186
Hot Hardness of Iron and Steel of Super Purity.....	188
Axial Fatigue and Stress-Rupture in Alpha-Beta Brass.....	190
New Dynamic Test.....	192
Effect of Bainite on Strength.....	196
Silicon Improves Ultra High-Strength Steels.....	196
Impact Properties of Leaded Steels.....	198
Ductile Chromium Metal.....	200
"Brittle" Fracture in Gray Iron.....	204

Microstructure of 18-8 Ti.....	206
Changes in Modulus With Alloying.....	208
Mechanical Equation of State.....	211
Transformation of U-Mo Alloys.....	212
Oxidation Resistance of Cr-Ni-Fe Alloys.....	214
Work Hardening High-Manganese Steel.....	218
Evaluating Ultra High-Strength Steels.....	220
Transformation of Uranium-Base Alloys.....	222
Effect of Sulphur in Titanium Alloys.....	224
Complex Carbides in Cr-Co-Mo-Ti-Fe Alloys.....	228
Ti and B in Heat Resistant Steels.....	234
Precipitation Hardening of Cr-Mn Stainless Steels.....	236
Tensile Properties of Metals at Low Temperatures.....	238
Growth of Uranium During Thermal Cycling.....	242
Austenite Stability of Fe-Cr-C-N Alloys.....	244
Effect of Environment on Creep-Rupture Properties.....	252
Aging Reactions in Superalloys.....	254
New High-Temperature Alloy.....	258

Departments

As I Was Saying, by Bill Eisenman.....	5
Engineering Digests of New Products.....	19
Manufacturers' Literature.....	31
Personals.....	136
Advertisers' Index.....	347, 348

there goes the profit...

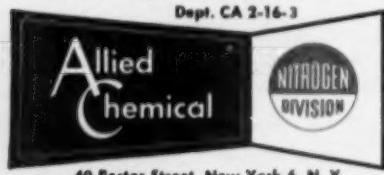


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As I was saying...



were at the Cleveland Convention room Greater Clevelander was tied up at the foot of Ninth Street to house A.S.M. members and guests during the Metal Congress and Exposition. If it cost \$22,000 (in advance) to move the boat from Buffalo to Cleveland, how much would it cost today? The answer is *not* \$64,000; that's the question.

You'll find the most complete and interesting program ever arranged by the A.S.M. The nine sessions of technical papers are all tops and have been selected by the Publications Committee with careful care. The A.S.M. Seminar on Saturday and Sunday on "Fatigue" is guaranteed to talk about it only — not to create it. The special session under the Industrial Heating Equipment Association, the two Educational Lecture Series, the Symposium on Thorium, the Special Clinic on Dies, the Annual Awards Luncheon on Tuesday, the 31 Alumni Luncheons on Wednesday, the Annual Banquet on Thursday, and the Distinguished Service Luncheon with "Young Engineers" as guests on Friday, and many other outstanding features will all combine to present seven days (and nights) ever to be remembered.

Let's not forget the Exposition using the entire capacity of Cleveland's mammoth convention halls where the 450 exhibitors will display their best and latest developments. Remember when we were able to "do" the show in one day? Not so anymore! It takes a minimum of two days in the show to "do" it well. It makes no difference what your problems are, you'll solve 'em quickly and correctly at the Metal Show.

Just completed contacting during the past chapter year and this summer all 96 chapters of the A.S.M. either individually or at regional groupings. The theme of the meetings was the planning of and for the 1956-57 chapter season. It was a fine report they were able to give of the past year — and a thrilling recital of the progressive steps planned for the coming year.

When all was said and done and the meetings over, I had forcibly impressed upon me again one fact that I recognized early in my association with A.S.M. and that was, "The Strength of the A.S.M. lies in its chapters and the chapters create that strength through the high character and unselfish service of the members of their executive committees."

A fact that was ever true.

See you all in Cleveland. It will be a pleasure.

Cordially,

Bill

W. H. EISENMAN, *Secretary*
American Society for Metals

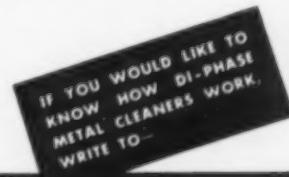


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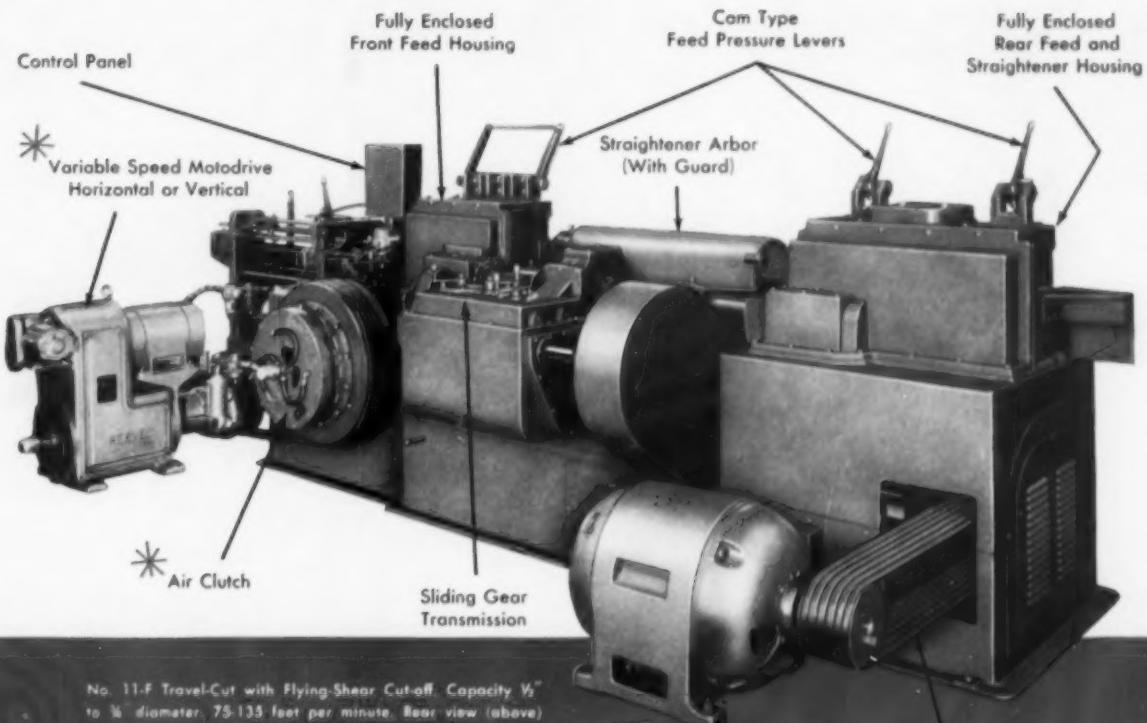
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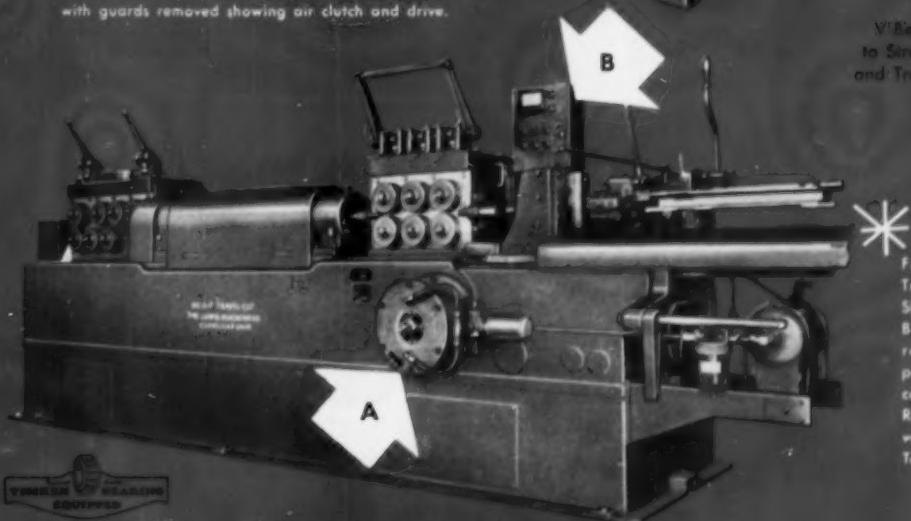
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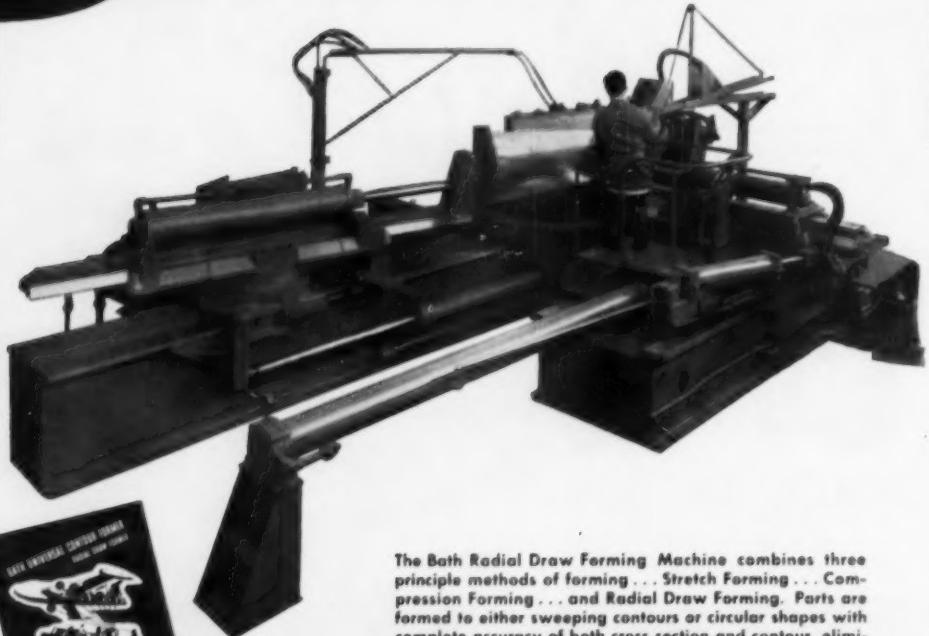


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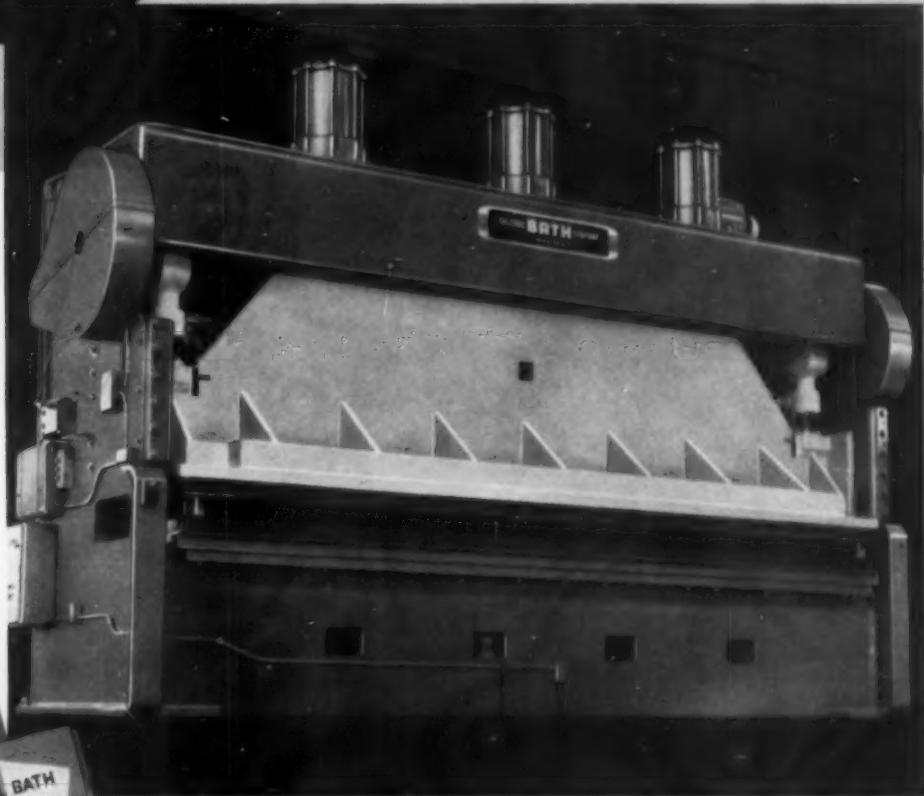


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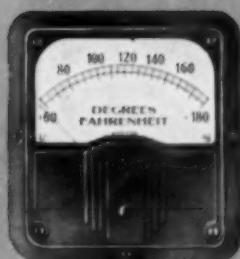
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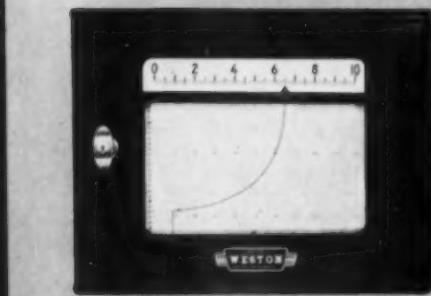
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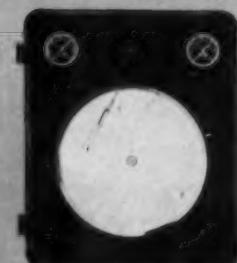


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CONTROLLERS

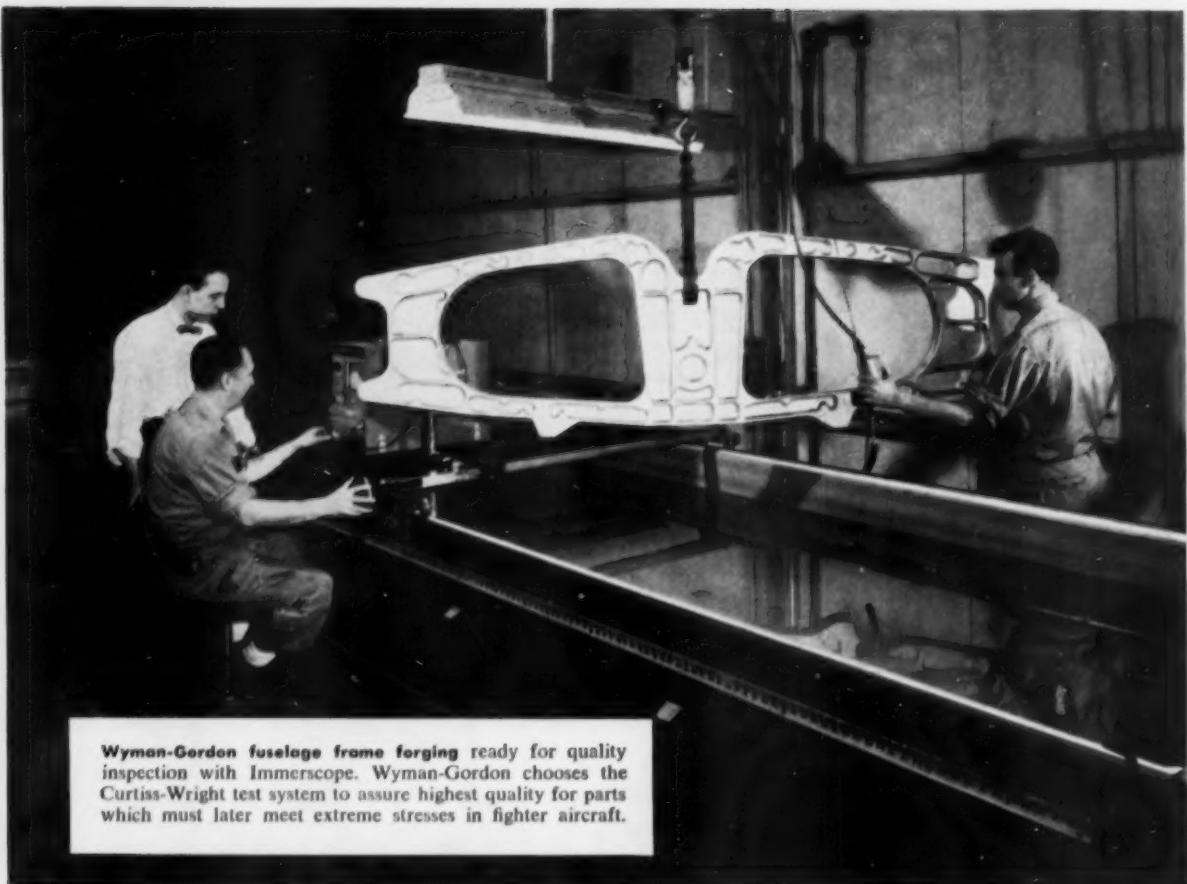


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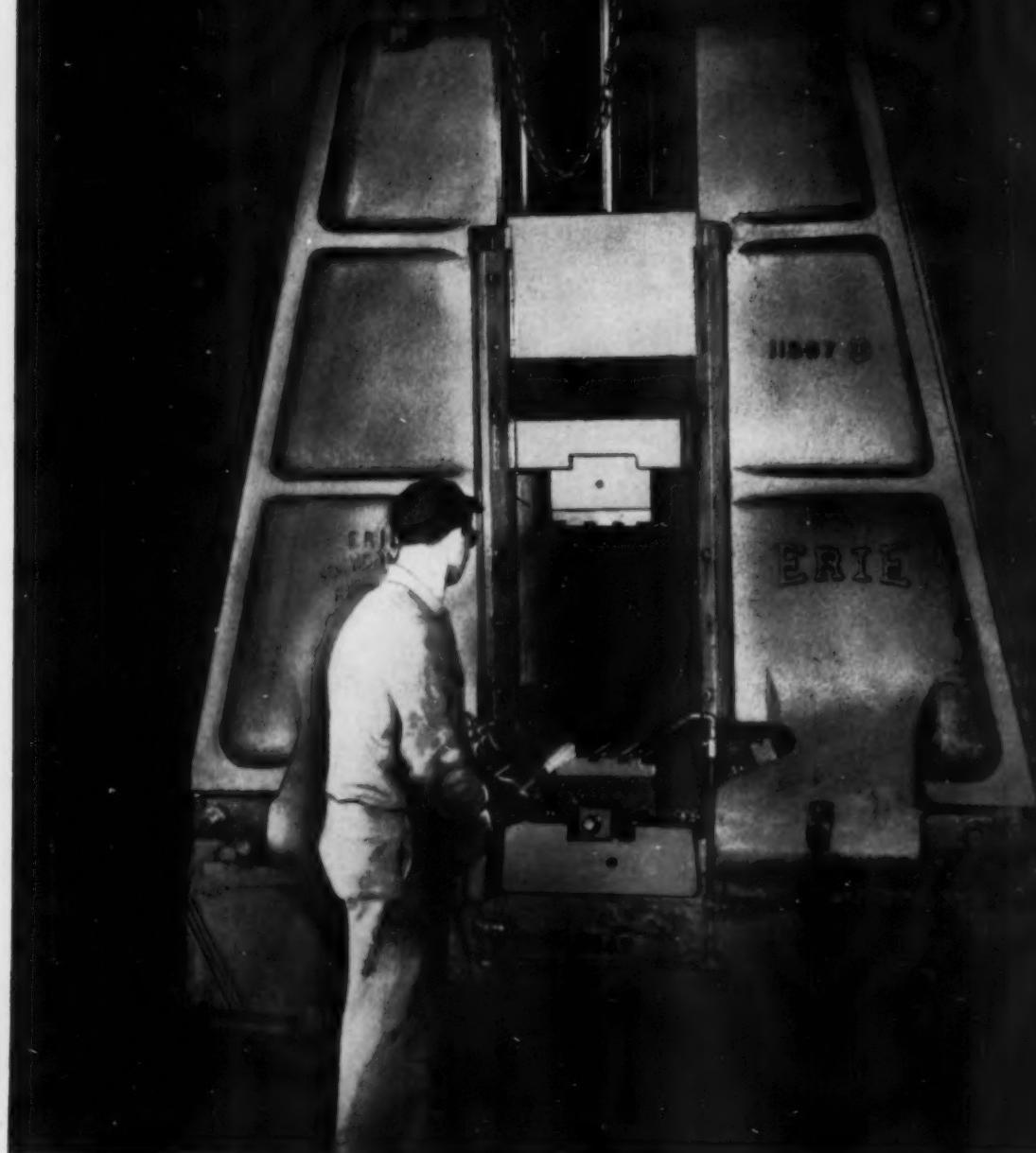
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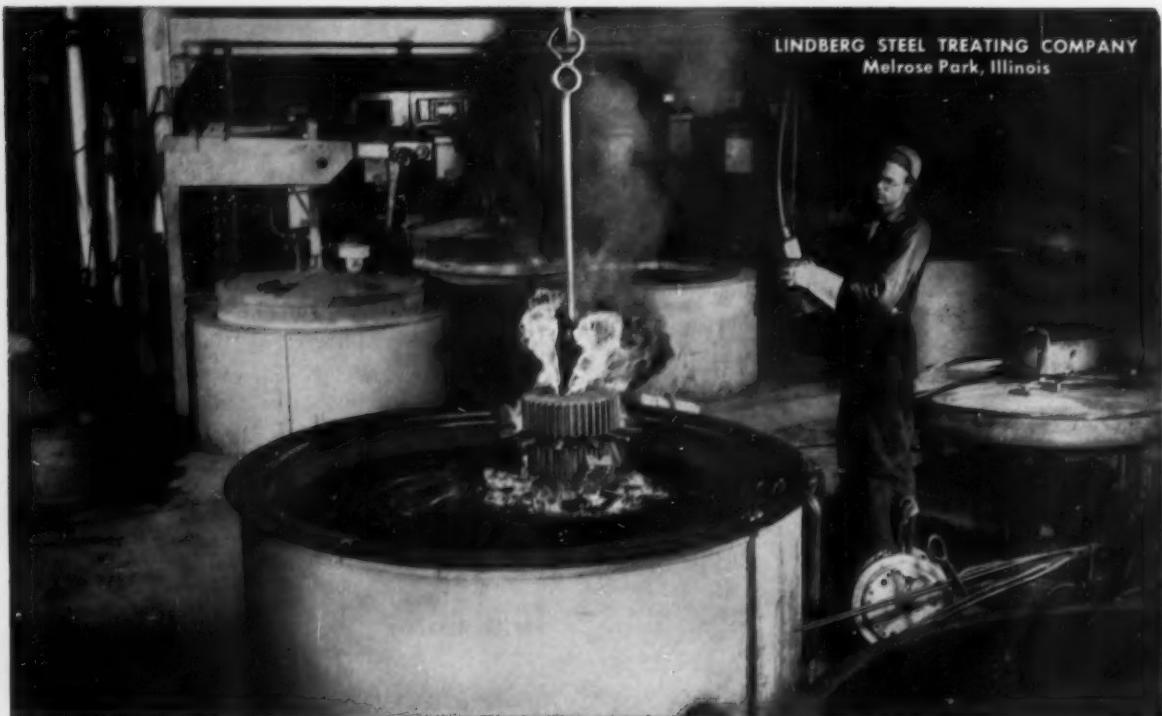
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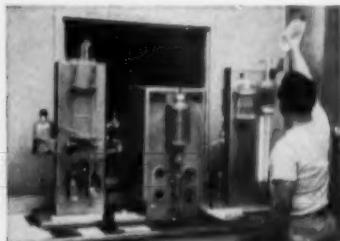
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SEPT. 1955

VOL. 3 NO.

NATIONAL
CARBON
COMPANY'S **CARBON AND
GRAPHITE NEWS**



A COLD-CHARGE SHOP MOVE AHEAD

A COLD-CHARGE SHOP MOVES AHEAD

...with the electric arc furnace!



By R. S. Lynch, President
Atlantic Steel Company, Atlanta, Georgia

■ Any growing company must periodically make basic decisions concerning expansions of capacity, weighing carefully all the factors involved to insure continued growth and profitable operation.

Atlantic Steel, an all open hearth shop for 50 years, has increased melting capacity several times during that period. Again faced with the need for major expansion in 1951, the logical question was — further increase of open hearth capacity or installation of electric arc furnaces?

Through the years, as the chart on the facing page indicates, we had taken one step after another to increase the ingot capacity and efficiency of our open hearth facilities. In the postwar period, it became evident that we were approaching the limit of such measures and that a new capital investment was necessary. The decision we made was to invest in electric arc furnaces.

Several years of successful experience with our first 75-ton unit then dictated the installation of a second furnace.

Consequently, we now have acquired an ample basis for direct comparison of the electric against the open hearth on cold-melt, low carbon steel operations — making the same grades of steel,

with the same personnel, and using the same raw material sources. The results of our experience show that our original decision was wise. The major advantages we have realized are:

LOWER FIRST COST. Our entire investment in the electric melt shop has been about 40% less than it would have cost to put in the equivalent open hearth capacity.

SAVINGS IN SPACE. Since our ground space is limited here in Atlanta, we appreciated the fact that the new melt shop, providing room for a total of three electric furnaces, takes up a third less space than would new open hearths producing the same tonnage.

FAST CONSTRUCTION. Each of our management decisions has been quickly transformed into new melting capacity. Because of the compactness, pre-fabrication and simplicity, an electric shop can usually be built more rapidly than an open-hearth shop of like capacity.

NET TONS

400,000

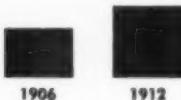
EXPANSIONS OF MELT CAPACITY

300,000

Atlantic Steel Company

200,000

100,000



Installation of original open hearths,
35 tons each

Enlargement of the three open hearths to
60 tons each

Enlargement of open hearths to
75 tons each

Improvements in melting and pouring
practices

INSTALLATION OF TWO
75-TON ELECTRICS
(RED BARS)

QUALITY CONTROL. Because our end-products require a wide range of carbon steel analyses, the electric furnace is particularly suited to our operation. Features important to us are precise temperature control and the absence of contamination from fuels.

FASTER HEATS. The four-hour heats of the electric furnace are a real boon to a custom shop such as ours. With adequate transformer capacity, we find that the only effective limitation on the heat input is the rate at which the scrap can absorb the heat.

FLEXIBLE OPERATIONS. We can produce electric steel according to demand — running the arc furnaces any number of shifts and any number of days per week. They start up quickly and shut down even more quickly, requiring the operator's attention only when producing steel.

LOWER OPERATING COSTS. Within six months after our first electric furnace was installed in 1952, it was producing steel at a lower net cost per ton than our open hearths which were working on the same grades. After the second furnace went into operation last fall, the economic advantage of the electric shop increased still more because of the reduction in its "cost above".

It should be emphasized that our shop produces no analyses outside of the low-carbon range — none of the high-priced alloy or stainless steels for which the electric furnace is usually required — yet we find that the arc has consistently reduced our costs and improved the efficiency of our operations.

We estimate that electric melting has reduced our ingot costs an average of 5%, compared to open hearth costs. Naturally, this figure varies somewhat with the cost of various raw materials. The cost advantage would also be different for other regions and end-products, but industry studies indicate that other non-integrated producers can also expect a substantial reduction of ingot costs with conversion to the electric furnace.

While on the cost factors, it is important to note that our power rates of 9-10 mills are neither high nor low as such rates go. Also, we have held our mold costs at about the same level as with the previous open hearth operation, by taking readings with immersion thermocouples to insure that electric furnace heats are not poured at excessive temperatures. And, we find that the electric furnace has reduced our costs for preparation of the scrap.

The flexibility and versatility of the electric shop are important operating factors to us because of the wide variety of our products. Since our founding, in 1901, to make cotton bale ties and turpentine barrel hoops, the list of products sold

under our trade-mark of "Dixisteel" has been steadily widened to include a complete line of merchant bars, reinforcing bars, fencing, nails, wire, small shapes and many other items. Hence the unusually wide variety of steel analyses — ranging from 5 to 40 points of carbon — and the extreme emphasis on flexibility in the Atlantic melt shop.

Some details of our electric shop experience may be of interest. We made the complete change-over with our regular open-hearth crews, excepting only an electric furnace melter hired from outside the company. Our personnel soon became skilled on the new furnaces and the training problems were minor, considering the scope of the change.

A most dramatic feature, of course, is the melt-

ing speed. The average heat cycle in our electric shop is four hours, but a good many heats approach the shop record of 2 hours and 45 minutes from charge to tap. The best heat we ever achieved with the open hearth was 7 hours, and our average was 8 hours. The slow charging operations on these open hearths made a painful contrast with the speedy top charging of our electrics. Our average output with open hearths ran about 8.5 tons per hour, but our electrics are running at almost twice that tonnage.

Another feature of the arc furnace which we find quite important is the ability to switch from single slag to double slag methods at will.

Our experience is 95% availability with the electrics where it was 90% with the open hearths.

New \$8½ million combination rod and bar mill — one of the world's fastest, with output of 5,000 feet of rods per minute and 40-50 tons of merchant bar products per hour — is part of Atlantic Steel Company expansion program.



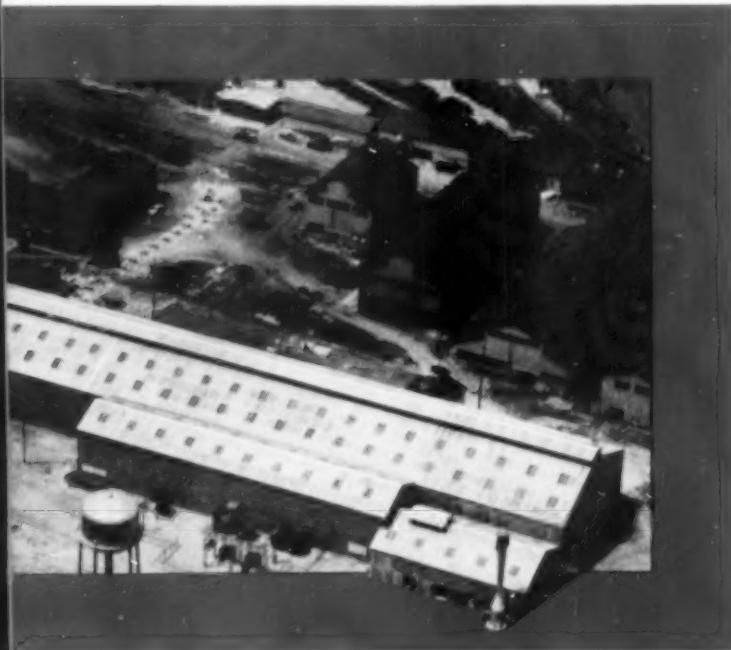
Some reasons for the difference are obvious. A spare roof can be put in place in three hours. Complete relining, except for the furnace bottom, requires only 12 hours. As you might expect, our maintenance costs have been cut by more than 50%. Furthermore, it was our experience with open hearths that production began to drop off sharply toward the end of each furnace lining campaign, whereas the electric furnace maintains the high level of output throughout the life of a lining.

We see a great future for the electric arc melting of low-carbon "work-horse" grades of steel in bulk tonnages. And we look forward to the time when regional demand will require the installation of a third electric furnace, with propor-

tionate expansion of other facilities.

Actually, such a time should not be so far away. We look forward to continued growth with plenty of competition to keep us on our toes and the electric melt shop to help us meet it on an equal basis.

To sum up the way we feel about our decision to install an electric melt shop, let me quote an experienced open hearth man who has gone through the entire change-over with us. J. E. Wilbanks, our Superintendent of Melting, says, "Electric furnaces can do everything that open-hearth furnaces can and do a better job of making quality steel at lower cost."





**WHAT NATIONAL
CARBON'S NEW
SERVICE PROGRAM
MEANS TO ONE
ELECTRIC MELT SHOP**

**The TIMKEN
Roller Bearing Company**

■ April's Carbon and Graphite News announced the latest revision of a long-time National Carbon technical service — a concentrated electrode service program to help operators obtain the best possible electrode efficiency. This program, extending the company's customer service policy, is capsuled in a presentation of approximately an hour's duration. First given in Pittsburgh last December before the Electric Furnace Conference of the A.I.M.E., 38 customer meetings have been held by the National Carbon Electrode Service Group with enthusiastic response. The program is paying off in improved electrode performance, lower costs and an altogether better operator understanding of electrode operation.

For this interview, your Carbon and Graphite News Reporter has visited Timken Roller Bearing

Company to bring you an on-the-spot discussion with Melting Superintendent, H. F. Walther; Assistant Melting Superintendent, L. D. Petersen; General Foreman, R. C. Roth; and First Helper, M. Podoliak. We asked these gentlemen to comment on the National Carbon program which had just been presented to a typical Timken melt shop group.

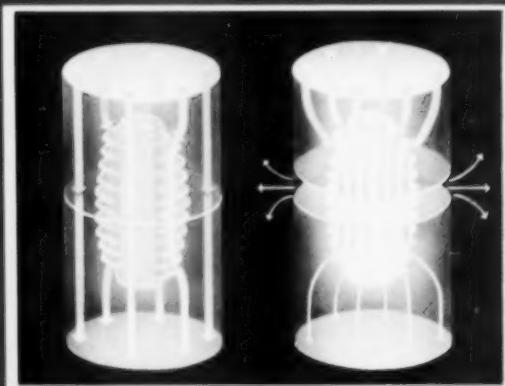
Q. Gentlemen, obviously from the group's response here tonight, you people are very much interested in electrode operation. We all know that electrode costs are an important consideration in electric furnace operation — do you feel that our program will help you reduce these costs?

A. Let's put it this way. Electrode costs and elec-



Pitch-reservoir*
nipple keeps
electrode joints
tight.

* U.S. Patent No. 2735705



Good joining gives efficient current flow.

Open joint heats up nipple, causes breakage.

tric power costs are two major items in producing electric furnace steel which together account for about half of our "cost above".

We've been preaching this idea right along, so we were especially glad to hear your technical people emphasizing the do's and don'ts that make for best electrode performance at lowest cost. As a matter of fact, we'd say that if we could have reduced our electrode consumption as little as one half a pound per ton last year, we would have shown a cost reduction of approximately \$80,000!

Q. That's an eye-opening observation — let's hope you'll be able to chalk up a cost reduction like this in the near future. Now, suppose you were to name one operational problem that stands out above all the rest, what would you pick?

A. There are several, of course. Electrode breakage resulting from falling scrap can be one of the most troublesome, perhaps. At The Timken Company, we strive to avoid this by correctly placing our scrap within the furnace. We have emphasized to our people how improper scrap placement can lead to scrap "caves", and how this falling scrap can strike electrodes hard enough to break them. We were glad to see the importance you attached to this in your color slides and talk. Calling attention to the problem graphically like that helps our operating people visualize even better the necessity for placing heavy scrap on the bottom of the furnace — medium to light scrap above.

Q. A good portion of the time was spent here tonight discussing good joint-making procedure.

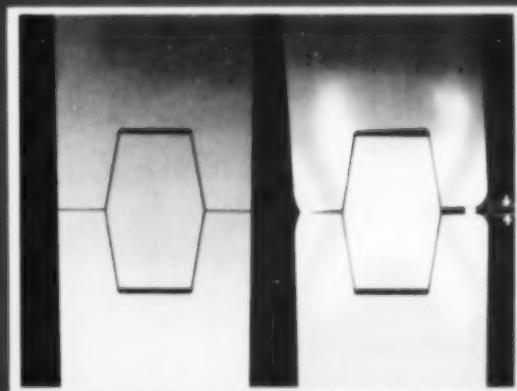
Two points particularly seemed to stimulate a lot of interest: first, the importance of starting with a clean, chip-free end face and socket; and, second, the whys and wherefores of our recommendation that the connecting pin, or nipple, be added to the bottom of the old electrode rather than to the top of the new one. Would you like to comment on these points from your own experience?

A. Well, as to the matter of clean, chip-free end faces — it's easy to appreciate the desirability of maintaining maximum possible physical contact between the end faces of joined electrodes. Since $\frac{2}{3}$ of the electric current goes through the end faces, we certainly want to avoid increased resistance at these interfaces. And, for the same reason, the sockets should be chip-free and clean so there will be no restriction between connecting pin and both sockets. It was good to hear you develop these thoughts further in your talk. Actually, that demonstrator unit of yours showed us more graphically than anything else we've ever seen just how seriously a lack of intimate electrical contact at the joint can affect electrode performance. It was easy for our men to associate the demonstrator's brightly glowing lamps with the unrestricted passage of current that results from a good, clean, tight joint. And, conversely, the dimly glowing lamps readily got across the idea of the poor passage of electrical current which occurs when joints are improperly made. You people must be receiving considerable comment from the field on this novel demonstrator unit.

Q. Yes, that's right — we're getting a lot of evidence that it's helping promote a better understanding



Use air hose for easy, sure removal of chips



What happens when chips remain on the face

of just what does take place at the electrode joint. And, it also helps operators understand some of the reasons for our recommended electrode handling practices. Perhaps there was some development touched on tonight that impressed you particularly — something you'd like to comment on?

A. One especially — we think one of the most significant developments in the electrode field in many years is your new pitch reservoir nipple. It has enabled such an improvement in joint-making practice that electrode and nipple breakage from unwinding has just about been eliminated in our shop. This has reduced electrode consumption.

You know, here at The Timken Company we were one of the first shops to recognize the potentialities of this new pin — and, we were one of the first to adopt it. Your cut-a-way color slide tonight showed our men exactly how the pitch in this new pin cokes under heat to lock the electrode joint

firmly together. This was particularly well illustrated, we thought.

Q. Well, gentlemen — we certainly have appreciated the chance to meet with you here at Canton tonight and exchange ideas. As a parting shot, if you had to pinpoint the most valuable aspect of these meetings, what would it be — where would you say they're most helpful?

A. We think it's been a big help in two ways. First, your vivid presentation of the basic factors underlying our electrode costs has highlighted the problems our furnace crews face everyday. Second, there's no doubt, after the free give-and-take discussion here, that our men will put a lot of these basic ideas into practice, resulting in a long-term benefit to our company. In fact, we expect this will stimulate many more discussions of our own. Thanks for coming.

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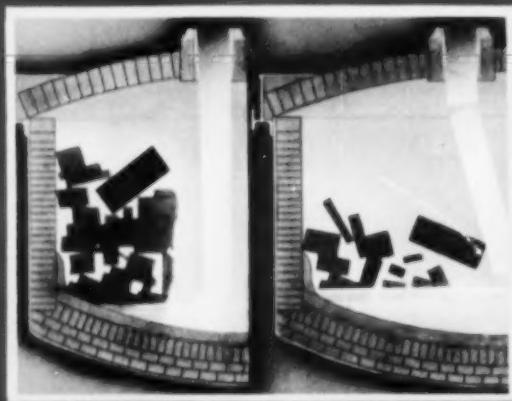
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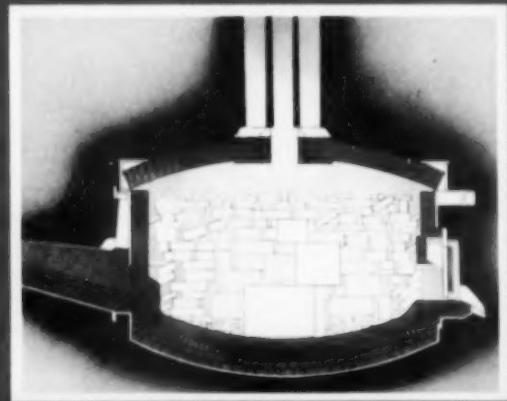


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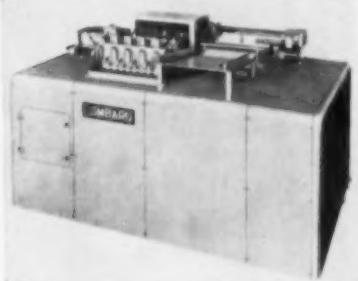
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APPLICATION and EQUIPMENT

new products

Induction Heater

A completely redesigned induction billet heater has been announced by the Lombard Corp. Entire furnace operation is controlled by one push button. Any degree of taper or uni-

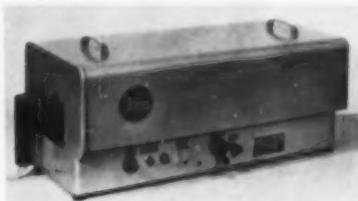


form heating is obtainable, with slight adjustments and coil construction is the same for aluminum, titanium, cupronickel or steel. Coils are cooled by water paths that are individually protected. No shut-down or warm-up time is necessary.

For further information circle No. 571 on literature request card, page 48-B.

Spectrometer

A new grating type scanning spectrometer has been announced by the Jarrell-Ash Co. Advanced optical design results in a first order reciprocal linear dispersion of 16 Å per millimeter at the exit slit, with a mini-



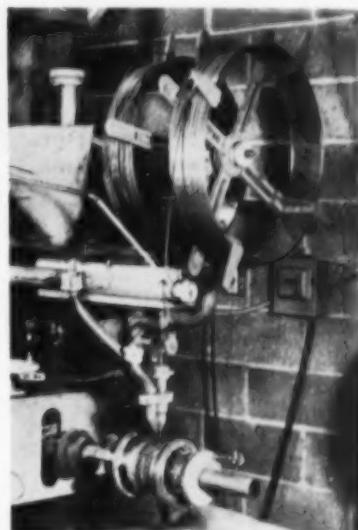
mum resolution of 0.2 Å. It is adaptable for use as a flame spectrometer, capable of detecting impurities to one part per billion. Among the features is a linear wavelength scanning mechanism which requires only a simple counter to indicate first order wavelength. A built-in 8-speed motor

drive permits variable speed scanning in either direction, with manual drive also provided.

For further information circle No. 572 on literature request card, page 48-B.

Hard Surfacing

New copper-coated, alloy-filled wire, for automatic and semi-automatic hard surfacing has been announced by the McKay Co. The wire



produces chemically uniform welds comparable in performance to those of solid wire. It is available in $\frac{1}{8}$, $\frac{3}{16}$, $\frac{5}{32}$, $\frac{3}{16}$, and $\frac{3}{32}$ in. diameters. The illustration shows welding a hard surface overlay to a tractor roller.

For further information circle No. 573 on literature request card, page 48-B.

Thickness Measurement

A new X-ray fluorescence instrument permitting continuous determination of thickness of a metal coating to 0.000001 in. has been announced by Applied Research Laboratories. The three primary components of this equipment are the X-ray head, the high voltage source and the ratio recorder. X-ray head is a self-contained

assembly including the X-ray tube and two detector heads. The high voltage source is a cased unit mounted next to the line. The ratio recorder comprises a strip chart recorder, ratio amplifier and high voltage Geiger supply.

For further information circle No. 574 on literature request card, page 48-B.

Titanium Descaling

Titanium forgings as well as other formed parts are now being descaled through the molten-salt-bath process, it has been announced by Kolene Corp. Advantages of the process in cleaning titanium aircraft forgings are: metal loss is reduced to a minimum, there is no etching and no hydrogen pickup, even when immersed for long periods of time. Parts such as aircraft turbine buckets and blades, which accumulate a heavy oily scale in service, are now being reconditioned by the process.

For further information circle No. 575 on literature request card, page 48-B.

Measuring Microscope

A new measuring microscope which reads direct by vernier to 0.01 mm. on both the horizontal and vertical scales has been announced by the Ealing Corp. The instrument focuses by rack motion and has a 2 in. achromatic microscope objective, with a



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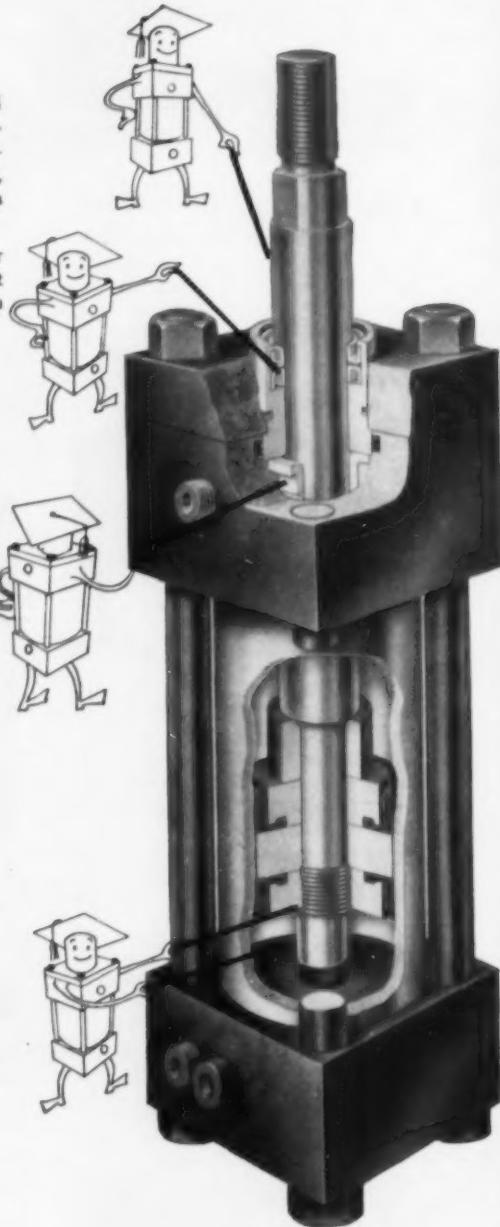
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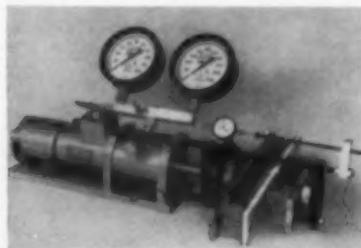
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focal length of 38 mm., as standard equipment. It has a magnification of 33 times, an object field diameter of 2.0 mm. and a working distance of 45 mm. The new instrument will measure in either horizontal or vertical position.

For further information circle No. 576 on literature request card, page 48-B.

Tensile Testing

The Cal-Testing Machine Company has announced a new tensile testing device and fixture. Adaptable for ten-



sion, compression, or flexural testing when fitted with the proper accessories, the Cal-Tester provides a constant rate of strain and load for testing metallic or non-metallic materials in rod, strip or sheet form. The Cal-Tester has load ranges of 1000 and 5000 lb., divided into increments

of 5 and 20 lb. on two 6 in. Bourdon tube gages. The unit is equipped with a precision shut-off control and automatic piston check to protect it from overloading or overtravel in either direction.

For further information circle No. 577 on literature request card, page 48-B.

Titanium Wire Cloth

Cambridge Wire Cloth Co. has announced the availability of industrial grades of wire cloth woven from titanium wire in mesh sizes ranging from 60 mesh down through the coarser sizes. It is intended for use in filtering or screening highly corrosive materials. In one instance, titanium cloth has been in service for more than 7 mo. with no evidence of corrosive attack whereas the previously used stainless steel cloth showed severe pitting after only 1 to 2 wk. of service.

For further information circle No. 569 on literature request card, page 48-B.

Silver Plating

A new Silvrex bright silver plating process has been announced by Sel-Rex Precious Metals. Besides giving a mirror bright finish directly from the bath, hard (Brinell 135) and ductile deposits result. It operates

at room temperature, has less fumes and less tendency toward bath decomposition. Range of current densities is from 10 to 40 amp. per sq. ft. For further information write No. 570 on literature request card, page 48-B.

Heat Exchanger

A new type of impervious graphite heat exchanger for both heating and cooling nickel plating solutions has



been announced by Falls Industries, Inc. It consists of only three parts—a one-piece floating impervious graphite heat transfer cylinder, a one-piece header dome, and shell with required nozzles and mounting brackets. One unit in operation heats 7000 gal. of solution in 6 hr. from 95 to 160° F. During plating operations, this same exchanger is used to cool the bath.

For further information circle No. 578 on literature request card, page 48-B.

Plate Clamp

An electromagnetic plate clamp, designed to aid in industrial welding jobs, has been announced by Portomag, Inc. It is equipped with a ratchet lever jack, and a heavy duty (3000 lb.) magnetic pull, sufficient to



straighten out warped sheet steel. One of its most important applications is its use in plate alignment work for butt welding operations. For further information circle No. 579 on literature request card, page 48-B.

Furnaces

A new line of oven furnaces for use in tensile, compression and bending tests has been announced by the Marshall Products Co. These furnaces are equipped with a fan at closed end of oven to provide air circulation and temperature uniformity. Viewing windows, hand holes and

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METAL PROGRESS

other access ports are furnished to meet individual requirements. They are also available in various sizes and two different temperature ranges, 100 to 900° F. and to 1350° F.

For further information circle No. 580 on literature request card, page 48-B.

Degreaser

Circo Equipment Co. has announced a new metal parts degreaser for cleaning parts that have a tendency to nest or pack, or parts that have recesses difficult to penetrate with a hand spray. The OP3 cleaning cycle is based on a consecutive boiling solvent, warm liquid and vapor dip and will remove tightly adhering greases, oils, tripoli and rouges.

For further information circle No. 581 on literature request card, page 48-B.

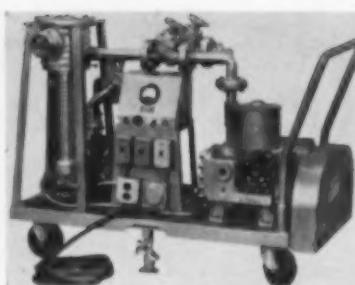
Controller

A new Series 500 air controller has just been announced by the Bristol Co. The controller is offered for measuring and controlling such variables as pressure, vacuum, temperature, liquid level, flow, differential pressure, and mechanical motion. Control modes available include narrow band (on-off), proportional, reset, derivative, and reset plus derivative.

For further information circle No. 582 on literature request card, page 48-B.

High-Vacuum Pump

For general laboratory work, for pilot plant operations and small scale production applications, Kinney Mfg. Div. has announced a new portable high-vacuum pumping system. Designed to attain absolute pressures as low as 10^{-6} mm. Hg, the new mobile system employs a fractionating



4-in. diffusion pump, connected to a 15 c.f.m. two-stage roughing and backing mechanical vacuum pump. Service connections required are a single phase, 60 cycle, 110 to 115 volt a.c. outlet and a source of cooling water. The unit is recommended for use in exhausting 10 to 15 cu. ft. chambers for vacuum distillation, impregnation, coating, degassing and stress relieving.

For further information circle No. 583 on literature request card, page 48-B.



ency to nest or pack, or parts that have recesses difficult to penetrate with a hand spray. The OP3 cleaning cycle is based on a consecutive boiling solvent, warm liquid and vapor dip and will remove tightly adhering greases, oils, tripoli and rouges.

For further information circle No. 581 on literature request card, page 48-B.



tric contact arm is now supported by a rigid bar against which the arm is preloaded in bending in order to make a firmer contact than was possible with a free floating arm. In addition, the extensometer has been arranged for following either extension or contraction of test specimens by means of a two-position toggle switch in the drive motor circuit on the control panel of the machine.

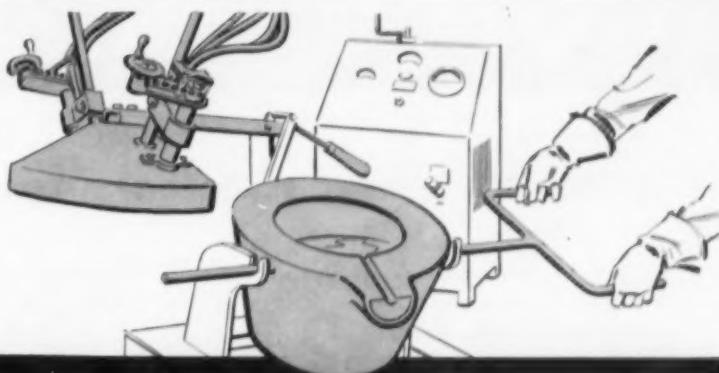
For further information circle No. 584 on literature request card, page 48-B.

Welding Machine

Taylor-Winfield Corp. has announced a new spot and projection welder with a welding ram pressure device providing precise control of welding force and forging impact. Electronic control synchronizes application of impact with start of welding current, or impact may be delayed. **For further information circle No. 585 on literature request card, page 48-B.**

Miniature Head for Thermocouples

The Marlin Manufacturing Corp. has announced a new screw type connection head for thermocouples, electric heating elements or swaged, magnesium oxide, insulated conductors. Stem sizes adaptable to the new con-



15 lb., 12 kw. Pot-Tilting DETROIT ELECTRIC FURNACE

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A versatile furnace! Converging indirect arc electrodes force arc down over metal for fast melting. Cover lifts and swings aside for charging and pouring. Pot can be transported or tilted to pour from stand. Permanent

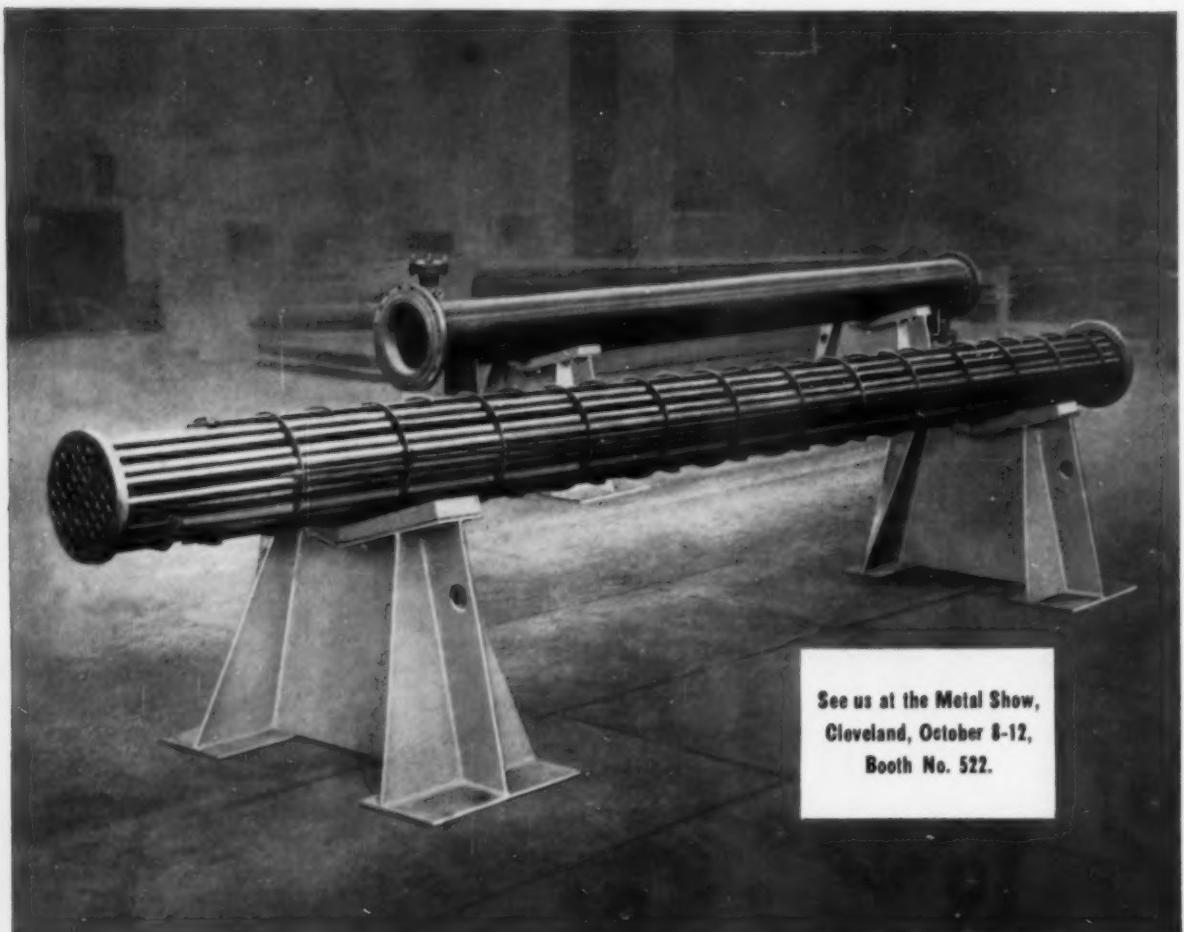
lining or removable crucibles. Complete with power and meters in separate cabinet.

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TITANIUM ... Strongest Defense Against "All-Out" Attack

In the ceaseless battle against corrosion, B&W Seamless Titanium Tubing is providing a first and most powerful defense.

B&W Titanium Tubing is the practical result of many years of experience in making tubes of carbon steels, stainless steels, other alloys. It superbly combines maximum corrosion resistance and easy workability.

For example, the superior qualities of B&W Titanium Tubing made it the natural choice of Struthers Wells Corporation for fabricating the all-titanium heat exchanger shown above. This unit, now performing perfectly in service, is 12 ft. long, x 17 1/2 inches diameter and weighs 2200 lbs.

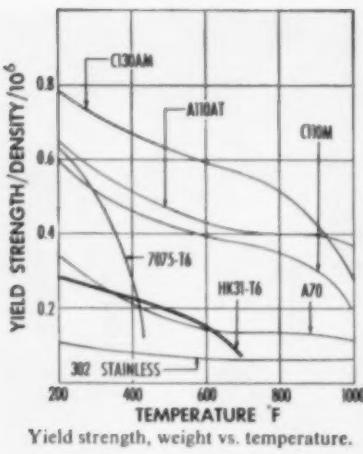
This case, like many others, shows how B&W Seamless Titanium Tubing met the need and solved the problem for a fabricator.

Get answers to *your* questions on why to use . . . what to use . . . how to use titanium tubing . . . write for Technical Data Card 185. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.



TA-5080(P)

Seamless and welded tubular products, seamless welding fittings and flanges—also in carbon, alloy and stainless steels



For High Strength-to-Weight Ratios at Elevated Temperatures—**TITANIUM and MAGNESIUM**

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To make this titanium pressurized tank, B&P welds two cylinders. Each is drawn in one operation. Tank withstands 5000 psi pressure.



Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.



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ductor head are 1/16 in., 1/8, 3/16, and 1/4 in. These new sizes will provide a screw-type connection between the small gaged thermocouple wires and the larger gage lead wires. Operating temperature ranges to 500° F. For further information circle No. 586 on literature request card, page 48-B.

Hardness Testing

In order to meet the growing demand for a portable hardness tester with unlimited capacity to test large

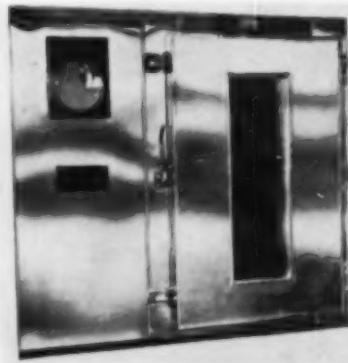


specimens, the King Tester Corp. has produced a chain device adjustable to the size of the piece to be tested. High strength chromium-molybdenum steel arms hold chain to test head allowing test head to remain rigid while chain takes full thrust of load. Fast Brinell readings are obtained regardless of size or shape of parts tested.

For further information circle No. 587 on literature request card, page 48-B.

Temperature and Humidity Control

The Webber Manufacturing Co. has announced an automatic control of both temperature and humidity in its environmental test unit. In environmental test equipment which requires control from -80 to +200° F., and 20% to 90% relative humidity, ac-



Luster-on

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ALUMINUM

Aluminum sealer replaces anodizing when hardness is not a prime factor. Protects well and offers excellent paint-bond.

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Chrome-like brilliance and corrosion protection at less than 1/5th of one cent per square foot. Long-lasting, easily controlled application.

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Khaki-drab protective finish giving a colored finish with excellent corrosion protection.

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One quick dip gives a uniform, low cost finish ideal as a base for later painting.

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Bright, clear coatings with no expensive handling, space-consuming storage or carboy deposits.

Data Sheets and Prices on Request

THE
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CORPORATION

78 Welles Ave. Springfield, Mass.



Now Completely Equipped With "Hot Rods." Part of a battery of nine electric strand bright annealing furnaces at the Dunkirk, N. Y., plant of Allegheny Ludlum Steel Corporation. Wire is annealed in these furnaces in alloy tubes containing a dissociated ammonia atmosphere. Operating temperature averages 2200°F. Furnaces are shut down after a five- or six-day working week.

Why Allegheny Ludlum converted to "HOT RODS"

Leading steel manufacturer reports longer life, improved performance, with CRYSTOLON® heating elements

Allegheny Ludlum Steel Corporation hoped to improve the varying performance and service life of the heating elements originally installed in their electric wire-annealing furnaces.

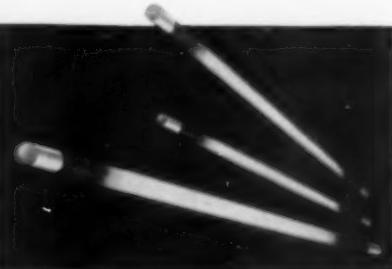
So, they converted all nine furnaces completely to Norton "Hot Rods" — and got the improvements they wanted from the very start. For example, one set of "Hot Rods" was recently removed after 10,000 hours of trouble-free service.

Proved "Hot Rod" Advantages

Many plants report Norton CRYSTOLON heating elements outlast other non-metallic heating elements

up to 3 to 1! This much longer life means savings in element costs, because fewer "Hot Rods" are needed. Also, you get reduced maintenance, due to less changing of elements or voltage taps. And "Hot Rods" help protect product quality because their slow, evenly matched rate of resistance increase means more uniform heating.

The big illustrated booklet, *Norton Heating Elements*, gives further facts on how "Hot Rods" can help improve your furnace operations and cut costs. For your copy write to NORTON COMPANY, Refractories Division, 328 New Bond Street, Worcester 6, Massachusetts.



Norton CRYSTOLON Heating Elements, or "Hot Rods," are a typical Norton Rx — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

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curacy can be held to $\pm 1\frac{1}{2}\%$. The control system followed a predetermined cycling time. High-low temperature, humidity and cycling control are available to meet any requirements.

For further information circle No. 588 on literature request card, page 48-B.

Rolling Mill

This combination 2-high 4-high rolling mill has been developed by Stanat Mfg. Co. It is employed as a utility



mill for the experimental rolling of small pieces at the Babcock & Wilcox Co.'s Nuclear Facilities plant. Ingots are heated between passes in the electric furnace at the left.

For further information circle No. 589 on literature request card, page 48-B.

Hot Salt Pump

Ajax Electric Co. has announced a new air-driven hot salt pump designed especially for pumping molten salts and hot metals. The pump is powered by an air-driven motor which is self-cooling. The pump body is made of a limited number of sturdy parts designed for operation under high ambient temperatures. Available in steel or with stainless steel submerged parts (for temperatures over 1000° F.), the pump has a maximum flow capacity of about 36,000 lb. an hour using 90 psi. air pressure.

For further information circle No. 590 on literature request card, page 48-B.



Germanium Rectifier

A new line of germanium electroplating rectifiers has been announced by Wagner Brothers. They utilize the new General Electric germanium "safety cell" hermetically-sealed to protect the germanium wafer from the deteriorating effects of moisture and corrosive fumes. Basic stacks

consist of six germanium cells, each with cooling fins. The stacks are of a standard design, are interchangeable, and are rated at approximately 500 amperes each. Every germanium cell is individually protected against circuit fault conditions and sudden overloads by fuses which break circuit. All units are forced air cooled, being equipped with an extra-capacity centrifugal blower.

For further information circle No. 591 on literature request card, page 48-B.

Nickel Plating

A new nickel plating process for use with their bright rhodium has been announced by Sel-Rex Precious Metals. The new process counteracts rhodium electroplate's tendency to cracking and peeling, when used as an undercoat.

For further information circle No. 592 on literature request card, page 48-B.

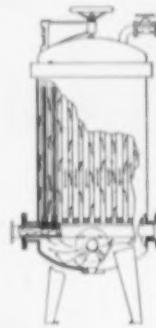
Cleaner

A new cold cleaner for spray washers has been announced by Klem Chemicals. This cold cleaner is a one package compound which is added to water 1 1/2 to 3 oz. to 1 gal. of water and is ready for use. It removes all types of soil including cos-

maline-type rustproofing compounds. Foaming has been controlled. For further information circle No. 593 on literature request card, page 48-B.

Vertical Filter

A number of new devices to increase filtering performance and convenience on vertical filters have been announced by Industrial Filter & Pump. Filter leaves that can be lifted from the manifold without unbolting, bottom and top outlet leaves, quick opening cover, jacketed shell, bottom opening filter chamber and individual leaf outlets are featured.



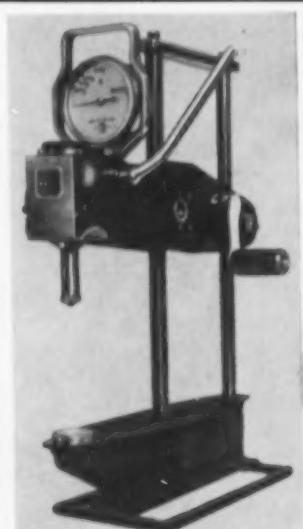
For further information circle No. 594 on literature request card, page 48-B.

Burnishing Compound

A new alkaline burnishing compound for zinc die castings has been announced by Oakite Products. Oakite FM 186 is an alkaline liquid

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QUALITY CONTROL PROBLEMS ARE SOLVED
WITH THE USE OF THE KING PORTABLE
TESTER: THE STANDARD OF ACCURACY
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For over a quarter of a century, King Portable Hardness Testers have set the standard for portable Brinell Machines. Precision testing of parts of any size, in any position, anywhere, utilizing a 3000 Kg. load on a 10 mm. ball giving a clear, sharp impression are features. This high standard of accuracy and performance has been integrated into a system of standard adapters for use with the basic unit, making the King Portable Brinell a machine of universal application. Wt. 28 lb.

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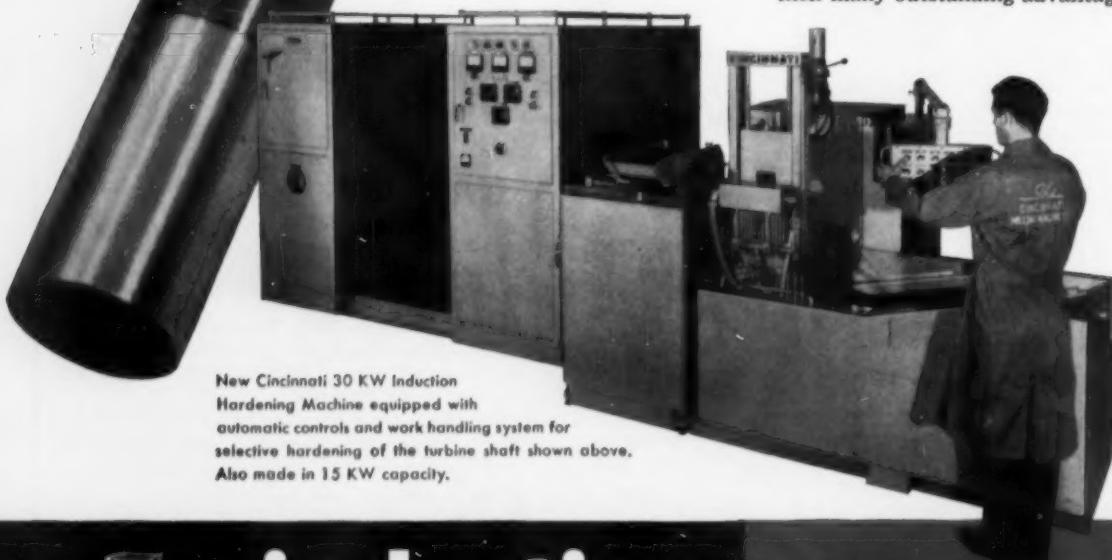
The work shown at left is indicative of the kind of performance you can expect from new

* Cincinnati Induction Hardening Machines. On the job in a fully automated installation, the machine illustrated below hardens two areas of this hollow turbine shaft to Rockwell C 60, .025" case depth, at the rate of 200 shafts per 42-minute hour.

Yet, the design of these machines makes them equally efficient for varied, low-production operations using manual control.

These are high frequency machines, operating at 1200 to 1400 kc/sec., for rapid selective hardening of small diameter or thin walled parts and those requiring a shallow case. High frequencies with maximum power density produce minimum case depth in minimum time, with little or no distortion and scale.

For full information on new Cincinnati Induction Hardening Machines, write for Bulletin M-1938. Better still, call in a Process Machinery Division field engineer. Let him brief you on their many outstanding advantages.



New Cincinnati 30 KW Induction Hardening Machine equipped with automatic controls and work handling system for selective hardening of the turbine shaft shown above.
Also made in 15 KW capacity.



induction
hardening

PROCESS MACHINERY DIVISION

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CINCINNATI 8, OHIO, U. S. A.

compound which may be used for self-tumbling or with shot or synthetic media. Recommended concentration of the solution is 1 to 2% by volume. Its use is said to produce a brighter finish and to improve the color of zinc die castings. It is also recommended for burnishing steel and copper.

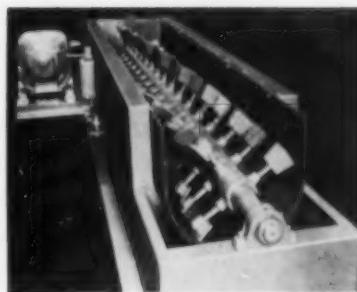
For further information circle No. 595 on literature request card, page 48-B.

Load Cell

Miniature SR-4 load cells for electrical measurements of forces and weights up to 10,000 lb. in compression have been announced by Baldwin-Lima-Hamilton Corp. These cells are less than 2 in. in diameter and only 2% in. high. They were developed to measure thrust forces in large steam turbines but may be used wherever space is too limited to permit use of standard cells of larger size. Calibration accuracy is within $\pm 0.25\%$ of full range at any load at 70° F. For further information circle No. 596 on literature request card, page 48-B.

Mixers

A new line of continuous mixers has been announced by the Gas Machinery Co. They will handle any size material from dust to 1½ in.,



either dry or in a slurry. All welded frame of heavy steel plate, standard replaceable mixer trough of heavy gage material, box-type construction are some features of the mixers.

For further information circle No. 597 on literature request card, page 48-B.

Brinell Microscope

The King Tester Corp. has announced its new line of Brinell scopes. Made of stainless steel, they are compact, lightweight and rugged. The lens has a patented 3-way construction and needs no adjustment to the eye. The microscope has a large opening in the side to utilize natural light and in addition, it has built-in illumination.

For further information circle No. 598 on literature request card, page 48-B.

HI-VAC announces

New Laboratory Vacuum Melting Furnace



Model
F-1212

Especially designed and engineered, The F-1212 Laboratory Vacuum Melting Furnace is extremely versatile and dependable. Completely self contained and compact, it is an ideal unit for development work and will answer practically every laboratory furnace need.

This new Laboratory Vacuum Furnace is resistance heated, tilt pouring, and will handle up to 12 pound melts of steel (other metals in proportion). Operation is simple and easy. Controls are readily accessible and are grouped within arm's reach. Gauges provide continuous, accurate readings and the HI-VAC pumping system is extremely fast and efficient.

Optional features include: turntable mold, dip thermocouple or optical pyrometer, provision for adding alloys. The versatility of this unit is demonstrated by the fact that (1) it can be converted to a high temperature heat treating furnace (2) a bell jar can be substituted for evaporating or coating (3) an adapter may be substituted which quickly converts it to a high capacity pumping system.

HI-VAC designs and manufactures a wide range of vacuum equipment for melting, heat treating, brazing, sintering, metallizing, impregnating, and crystal growing. See the extremely versatile Laboratory Vacuum Melting Furnace and other HI-VAC developments at the Metals Show, Booth 2716 . . . or write for complete details.



Tensile Testing

Fast!

Accurate!

Easy!

This compact machine tests spotwelds, strip, wire, anything within its 20,000 lb. capacity. Hydraulically powered, it has an easily controlled ram, self-acting specimen grips that are open sided for easy specimen insertion. This tester, Model ST-1, is adjustable to take specimens 5" to 9" in length. Various load gauges, grips, and other modifications are available.

**Write for more information—
give us your requirements.**

DETROIT TESTING MACHINE COMPANY

9384 Grinnell Ave., Detroit 13, Mich.

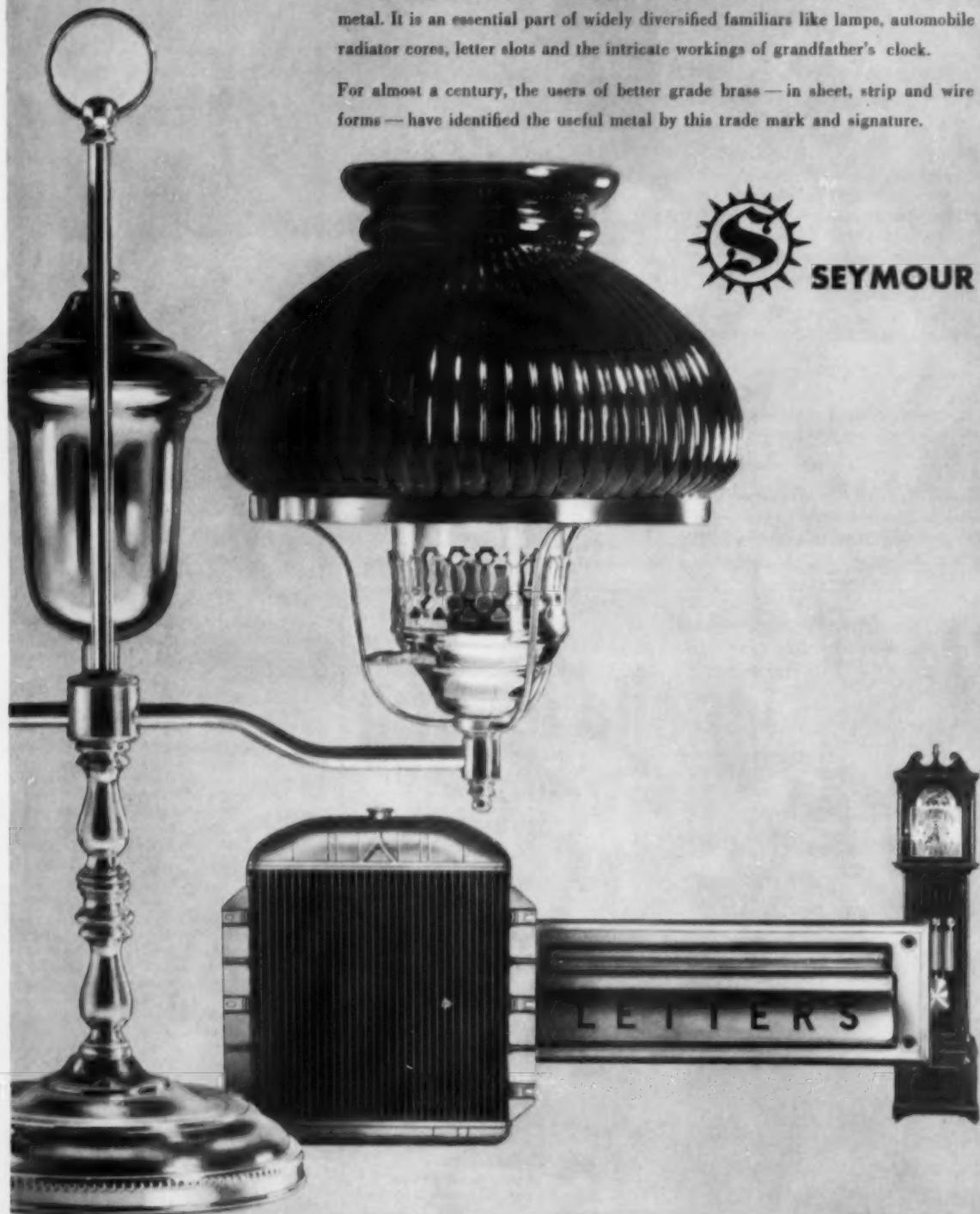


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APPLICATION and EQUIPMENT

new
literature

601. Abrasive Cleaning

Folder on Malleabrasive for airless blast cleaning equipment gives advantages, grades, equipment it may be used with and parts that may be cleaned. *Globe Steel Abrasive*

602. Abrasive Wheels

Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

603. Alloy Castings

8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

604. Alloy Castings

22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

605. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

606. Alloy Tools

44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

607. Alloy Tubing

Data Card 184 on carburizing, heat treatments, critical points, mechanical properties, welding and machining of 4100 series steel tubing. *Babcock & Wilcox*

608. Alloys

8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

609. Aluminized Wire

6-page booklet on aluminized steel wire and its applications. *American Chain & Cable*

610. Aluminum Bonding

Brochure on Alumi-coat process of bonding aluminum and its alloys to ferrous metals. *Arthur Tickle Engg. Works*

611. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

612. Aluminum Extrusions

Data on commercial aluminum extrusions. *Superior Industries*

613. Aluminum Extrusions

28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

614. Annealing

Reprints of article on continuous annealing of stainless steel sheets in roller hearth furnace. *Gas Machinery Co.*

615. Annealing Furnaces

8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

616. Arc Furnaces

Flexibility of the electric arc furnace —what it means to the steel producer, in *Carbon and Graphite News*. *National Carbon*

617. Atmosphere Furnace

Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

618. Atmosphere Furnace

Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

619. Atmosphere Furnaces

4-page bulletin on furnaces for hardening high carbon and high speed tool steels. Diagrams, specifications and performance data. *Lindberg Engineering Co.*

620. Atmospheres

12-page bulletin on use of protective atmospheres to prevent deterioration of metals during various heat treating processes. *General Electric*

621. Atmospheres

Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

622. Atmospheres

12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

623. Bearings

20 data sheets give special properties and case histories for new Rulon oil-free bearing material. *Dixon Corp.*

624. Bearings

Chart on chemical, mechanical and work characteristics of sintered bronze or iron bearing materials. *Bound Brook Oil-Less Bearing*

625. Beryllium Copper

4-page data sheet features a section detailing the specific methods for heat-treating beryllium copper. Engineering specifications including physical properties and the effect of these properties on heat treatment. *American Silver Co.*

626. Beryllium Copper

6-page booklet 7 on precision strip for electronics applications. Table of typical mechanical properties of beryllium copper, phosphor bronze, nickel silver, brass, gilding metal, chromium copper and stainless. *Penn Precision Products*

627. Black Oxide Coatings

8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

628. Blast Cleaning

New 8-page brochure No. 607 on air blast cleaning cabinet. Tables give dimensions and specifications. *Pangborn Corp.*

629. Blast Cleaning

Booklet on airless abrasive cleaning of shell molded castings for removal of sand, scale, discoloration and grinding lines. *Wheelabrator Corp.*

630. Brass

20-page pocket-size booklet on brass rod mill products. Weight tables, specifications and other technical data. *Titan Metal Mfg. Co.*

631. Brazed Tubing

12-page data book on brazed tubing made from copper coated steel. *Bundy*

632. Braze

8-page bulletin S-1050 on production brazing and soldering. Automatic brazing machine. *Selas Corp.*

633. Braze

16-page pocket-sized guide to selective fluxing for low temperature silver brazing. *American Platinum*

634. Braze

Low Temperature Braze News, No. 73, gives case histories. *Handy & Harman*

600. Cemented Carbides

"Designing with Kennametal" is a new booklet prepared specifically for design engineers. It begins with a discussion of basic design principles. The section on fastening by brazing discusses such topics as relieving



brazing strains, shrink brazing circular parts and shape of brazed joints. In addition, sections on cementing, mechanical fastening and finishing are included. The booklet concludes with a discussion of typical design problems and applications. The 44-page booklet is well illustrated and attractive. *Kennametal, Inc.*

635. Braze

Bulletin 589 on furnace and induction brazing installations and methods. *General Electric*

636. Braze Alloys

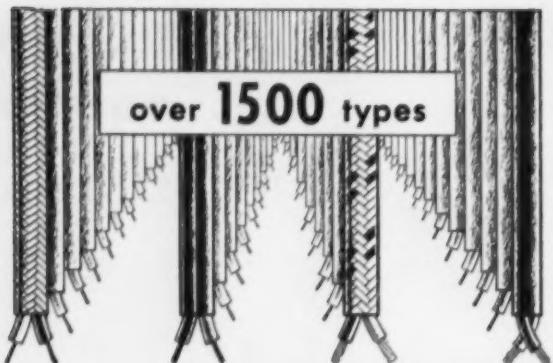
Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

637. Bright Annealing

6-page bulletin describes furnaces for annealing system for nonferrous metals. *Lee Wilson Engineering*

638. Brinell Machine

Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*



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Thermo Electric makes and stocks a countless variety of thermocouple and extension wires, both solid and stranded conductors—for any application, for all conditions. In fact, on T-E's shelves are over 1500 different wire combinations of advanced insulations, all standard calibrations, and gage sizes from 11-40—the widest selection known. Metallic armor overbraids of many hi-temp materials provide extra mechanical protection and electrical shielding. Whatever you need, in wire or multi-conductor cables, T-E has it. Prompt delivery.

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Rockwell "B" 5-100 Scale
Rockwell "C" 10-70 Scale

Rockwell "15N" 70-95 Scale
Brinell Medium 100-440 Scale
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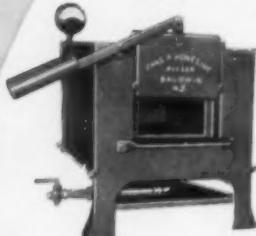
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Model CT-2
Price \$680

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...



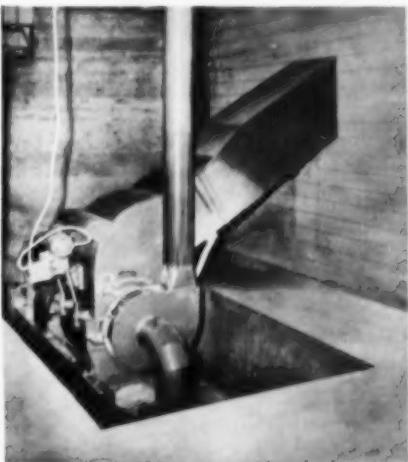
Lower-Cost Dirt. This mammoth coal stripping machine scoops out 2000 cu. yds. of overburden an hour, cuts the cost of stripping coal that lies under 50 to 80 ft. of overburden. Its 22-ft. wheel carries eight buckets, each 4 ft. wide, with lips of 2½-inch USS "T-1" Steel. USS "T-1" Steel has the strength and toughness to scrape through shale, rock, mud, and ram into ton-and-a-half boulders day in and day out. In addition, it is weldable in the field, costs less than other steels that could be used—and outlasts them. This wheel excavator was designed by United Electric Coal Companies, Chicago, for their own use.



Heavier Loads, More Production. Mack Welding Company, Duluth, Minnesota, has used USS "T-1" Steel to increase the durability and at the same time reduce the weight of its Orange Peel Type, Four Tine Pulpwood Grappling. With these new, lightweight grapples, crane operators can handle increased payloads with present cranes. As a result, production can be increased as much as 40 percent.

UNITED STATES STEEL CORPORATION, PITTSBURGH

UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST



Shucks, hay fodder, corn cobs, and grains are extremely abrasive when sucked out of a hammermill at high speed. And the blades of the fan that does the sucking must be able to withstand the abrasion and must be weldable. Myers-Sherman Company, Streator, Illinois, manufacturers of industrial hammermills, now make these fan blades from USS "T-1" Steel and save \$7 on fabrication of each fan. USS "T-1" Steel provides all the needed durability, as well as good weldability.

* COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

* TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

Moloney Saves A Ton. The size of everything had to be reduced on this new, smaller-than-ever portable transformer designed by Moloney Electric Company, St. Louis, Missouri. Over a ton of weight was saved in the tank alone by building it of ¼-inch USS "T-1" Steel instead of ¾-inch carbon steel. The very high strength of this heat-treated alloy steel made possible this 25% saving in weight. The excellent weldability of USS "T-1" Steel was important, too, because this portable transformer is permanently welded to the bed of a semi-trailer. This particular unit was designed for Oklahoma Gas & Electric Corporation. Shell was fabricated by Nooter Corporation, St. Louis.

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its excellent weldability can help you cut the cost of fabricating high strength parts, and to reduce repairs and maintenance expense.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Room 5397, Pittsburgh 30, Pa.



CONSTRUCTIONAL ALLOY STEEL

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



UNITED STATES STEEL

"This forging lost 33 tons along



says **Joseph Lacey,**
Supt. of Machine Shops
USS Homestead
Forgings Division



It was during the First World War, 38 years ago, that Joseph Lacey first toted his lunchbox as an apprentice machinist for United States Steel. He is now master of industrial machining, and has been entrusted with a large crew of machinists, inspectors and other experts who make USS Quality Forgings.

Visitors are always intrigued by the great difference between the ingot weight and the shipped weight of the forging. The picture, for example, shows a power station turbine rotor, one of our specialties. Forgings of this type have as much as 65% metal loss from ingot to shipped weight. Where and why did it go?

The nature of open die press forging on large ingots is such that considerable stock must be left on the various diameters of a contour forging. Top and bottom "crop" losses at the press, depending on various metallurgical factors such as ingot size and design, account for a considerable percentage of metal loss. However, other than "crop" losses, the open die press cannot remove large amounts of metal—this must be done in the machine shop.

When the forging arrives at the machine shop, special carbide tooling permits large amounts of steel to be "hogged off" through the use of high speeds and feeds and heavy cuts. This is known in the forging business as rough machining—fast removal of large amounts of metal. Rough machining is often accomplished in two stages—before and after heat treatment for physical properties. When specified, large masses of metal are removed in the preliminary rough machining operation known as "barking." After heat treatment, the machinist must "final rough machine" with sufficient stock allowance to permit the customer to finish the job to size in his machine shop.

So you can't skimp on steel if you want a superlative job—like a USS Quality Forging. A liberal, non-penny-pinching approach is needed, and that's what you get from United States Steel. Why not write for a free copy of our 32-page booklet that describes USS Quality Forgings? Address inquiries and booklet requests to United States Steel, Room 5397, 525 William Penn Place, Pittsburgh 30, Pa.

the way"



USS QUALITY FORGINGS



heavy machinery parts . . . carbon, alloy, stainless
forged steel rolls and back-up roll sleeves
electrical and water wheel shafts
specialty forgings of all types

UNITED STATES STEEL



BLAST FURNACE downcomer linings being gun-applied with Lumnite-concrete at Pittsburgh Works, Jones & Laughlin Steel Corp. Inset (left) shows blast furnace downcomer system lined with Lumnite Industrial Concrete.

Protect downcomer systems with Industrial Concrete linings

Abrasion and heat put Lumnite-concrete linings to the test in these big blast furnace downcomers. But once "shot" into place, Lumnite* gives long-lasting, smooth, jointless linings that effectively withstand rugged service conditions. If repairs are needed, they can be made quickly and easily—because Lumnite-concrete reaches service strength within 24 hours.

Such linings are just one of the many profitable uses for Lumnite calcium-aluminate cement in blast furnaces. Use it also for **Heat-Resistant** foundation pads in blast furnaces and stoves; **Refractory** linings in hot blast mains, where the easy placement of Lumnite-concrete simplifies the once intricate job of forming Y-intersections; **Refractory Concrete insulation** for stove domes; and for many other jobs where high-temperature service up to 2600°F. and durability are needed.

Keep a supply of Lumnite cement or prepared Lumnite-

base castables on hand for emergency needs. Packaged castables containing Lumnite cement and selected aggregates assure the right concretes for a wide variety of high-temperature applications. Castables are made and distributed by leading manufacturers of refractories.

UNIVERSAL ATLAS CEMENT COMPANY

UNITED STATES STEEL CORPORATION SUBSIDIARY

100 PARK AVENUE, NEW YORK 17, N. Y.

*"LUMNITE" is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

L-128
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United States Steel Hour—Televised on alternate Wednesdays—See your local newspaper for time and station.

639. Burners

New bulletin and data sheet on series 214 burners give advantages, capacities, specifications. *North American Mfg.*

640. Burners

8-page Bulletin SC-1004 on ribbon burner describes burners, heating techniques and gives selection data. *Selas*

641. Burners

Bulletin on pulsation-type oil-gas burner for annealing furnaces, baking ovens, billet heating, heat treating and forging furnaces and many others. *Radiant Products Co.*

642. Calibrating Machine

Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

643. Carbon Analyzer

8-page booklet on equipment for hydrogen and carbon determination in titanium, zirconium, iron, steel and heat resisting alloys. *National Spectrographic Lab*

644. Carbon Brick

Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

645. Carbon Dioxide Welding

12-page reprint on carbon-dioxide shielded consumable electrode arc welding. Methods of supplying and flow characteristics of carbon dioxide. Properties of weld metal, operating characteristics. *Air Reduction*

646. Carbonitriding

Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

647. Carbonitriding

Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

648. Castings

Literature on shell or sand castings of ArmaSteel, malleable iron or gray iron. *Central Foundry Div.*

649. Ceramic Tools

10-page report on machining steel with ceramic tools includes grinding ceramic tools, new-type tool holder, geometry of ceramic tools. *Norton*

650. Chromate Finishing

File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

651. Chromium Plating

New folder gives advantages of new additive. Tables of compositions of plating solutions. Charts. *Diamond Alkali*

652. Chromium Stainless

12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

653. Cleaner

Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

654. Cleaners

New 4-page bulletin on cleaners for preparing metallic surfaces for electroplating, anodizing, painting. *Hanson-Van Winkle-Munning*

655. Cleaning

44-page booklet, "Some Good Things to Know About Metal Cleaning", discusses tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

656. Cleaning

New 8-page bulletin on cleaning machines. Importance of mechanical agitation in parts cleaning. *Magnus Chemical*



SEE . . .

The new large Combination Type Laboratory Mill (No. 4-083) in operation complete with pay-off and take-up reels, dual motor power screw down, and force feed lubrication system. Can be used as a two-high mill or a four-high mill featuring driven back-up rolls or work rolls. Roll sizes $2\frac{1}{2}'' \times 8\frac{3}{8}'' \times 8''$. Maximum separating force, 300,000 lbs. at 100 fpm.

SEE . . .

The Fenn No. 6F Swager and Model 25H Hydraulic Feed in operation. Maximum capacity of the 6F Swager is $2\frac{1}{4}''$ diameter for solid stock and $4\frac{1}{2}''$ for tubing. The hydraulic feed is variable from 0" to $2\frac{1}{2}''$ /second with a return stroke of 12"/second. The feed insures a constant gripping force and prevents work rotation. Feed capacities up to and including 4" diameter tubing at 500 pounds thrust.

SEE . . .

The newest Model 4TH Combination Type Turks Head incorporating the features of both the Universal and Plain Types. Rolls are adjusted to conform to either arrangement.

SEE . . .

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FIRMNESS PARTICLE SIZE RANGE	SOFT (EASILY COMPRESSIBLE TO HIGH DENSITIES)		HARD (PRESERVE SPHERICAL SHAPE UNDER PRESSURE)	
	"NORMAL"	SPECIAL FOR HIGH Q	"NORMAL"	SPECIAL FOR HIGH Q
COARSE	L	GQ-4	E	J
MEDIUM	HP	GS-6	TH	—
FINE	C	—	SF	W

*C HAS MEDIUM PARTICLE SIZE RANGE, BUT IS HARDER THAN HP.

Let us send you a 32-page book giving characteristics and applications . . . We invite you to call upon our research facilities and Technical Service Department for assistance in developing new applications or new products involving the use of any of these powders. We also invite inquiries for powders whose performance characteristics are different from those exhibited by any of our existing types . . . Kindly address Department 50.

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657. Cleaning

New 8-page booklet on wetting agents, detergents, emulsifiers. *E. F. Houghton*

658. Cleaning Solvent

New 4-page folder on detergent-action safety solvent. Uses, advantages. *Turco Products*

659. Coatings

4-page bulletin on how pure metallized zinc or aluminum coatings prevent corrosion. Typical applications. *Metalizing Engineering Co.*

660. Cold Finished Steel

16-page booklet on 10 grades of cold finished steels. Analysis, machinability, heat treatment, wear resistance. *Jones & Laughlin*

661. Combustion Control

20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

662. Compressors

12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

663. Continuous Casting

24-page book, "Better by the Mile", describes how the Rossi continuous casting machine works. History of continuous casting. *Scovill Mfg.*

664. Controlled Atmospheres

Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

665. Controllers

16-page educational bulletin No. 9 gives data, operation diagrams, schematic drawings of capacitors. *Wheelco*

666. Controllers

80-page catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

667. Controllers

12-page booklet on temperature controls and special purpose controllers. Operation, design, installation. *Assembly Products, Inc.*

668. Copper Alloys

40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

669. Copper Alloys

24-page manual on alloys in rod form. Typical parts. Specifications covering alloys described. *Mueller Brass*

670. Corrosion Prevention

Full technical details on Turcoat 4178 aluminum conversion coating that stops corrosion of aluminum, improves paint adhesion and provides an ornamental finish. *Turco Products*

671. Corrosion Resistance

20-page bulletin on copper alloys for corrosion resistance. Table gives applications in 150 media. *Ampco*

672. Creep Testers

Data file lists 8 models, gives salient features, and illustrates them and uses. *Arkweld Mfg.*

673. Creep Testing

Bulletin 4420 describes long-time creep test machines, creep-rupture machines and relaxation machines. *Baldwin-Lima-Hamilton*

674. Crystal Models

Folder describes unique kit for constructing crystal models. *Harshaw*

675. Cut-Off Wheels

36-page revised manual on cut-off machines and abrasive wheels. *Norton Co.*



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"B"	375	515	645	1430	1650
"C"	(X)	565a	695	1365	1690
"D"	386	591	788	1541	(X)
Lempco Model No.	25 E-2	50 E-2	75 E-2	100 E-2	150 E-2
Rated Tonnage	25	50	75	100	150
Press Operation	2 H. P. PUMP UNIT				
*LEMPCO	\$825	\$875	\$1050	\$1720	\$1920
Competitor "A"	(X)	(X)	(X)	(X)	(X)
"B"	1430	1430	1650	(X)	2640
"C"	(X)	(X)	(X)	(X)	(X)
"D"	1147c	(X)	(X)	(X)	(X)

*Prices effective April 15, 1956 . . . F.O.B. Lempco Plant,
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676. Cutting Oil

Bulletin 39 on transparent cutting oil which is designed for use on a wide variety of steels. *Sun Oil Co.*

677. Cutting Tools

36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

678. Cyaniding

Production pot cyaniding with mechanical dump and load is described in the April issue of Metal Minutes. *Sunbeam Steel*

679. Decarburization

8-page booklet on effects of decarburization on tool steels tells what it is and what can be done about it. *Carpenter Steel*

680. Descaling

24-page book, "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U.S. Ind. Chem.*

681. Descaling

16-page bulletin 608 on how Rotoblast descaling machine operates, outstanding features, examples of its use. *Pangborn*

682. Descaling Process

8-page bulletin on sodium hydride descaling process for ferrous and non-ferrous metals. *DuPont*

683. Descaling Stainless Steel

Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

684. Degreasing

34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

685. Diamond Polishing

8-page booklet on metallographic polishing with diamond abrasive and its advantages over silicon carbides. *Elgin National Watch Co.*

686. Die Casting

New illustrated catalog on complete line of die casting machines. *Kuz Machine*

687. Die Sets

Catalog shows complete line of ball bearing die sets. *Lemco Products*

688. Electric Furnace

Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

689. Electric Furnaces

Brochure on electric heat treating melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

690. Electric Furnaces

Bulletin 441 on box-type electric furnaces diagrams and describes the furnaces and lists specifications. *Heavy Duty Electric Co.*

691. Electric Melting

Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

692. Electrocoated Wire

8-page bulletin on new wire materials—Nickelplated and Brassplated, electrocoated steel wire. How it may be formed, bent and twisted without breaking the coating. *National Standard*

693. Electrodes

16-page catalog of complete line of spectroscopic electrodes and powders. 27 special grade preformed electrodes illustrated and described. *National Carbon*

694. Electrodes

Folder describes two electrodes recommended for welding cast iron. *Metal & Thermit*

695. Electrodes

4-page bulletin describes characteristics, properties and sizes of five grades of bronze electrodes. *Ampco Metal*

696. Electrolytic Metals

New 4-page folder on analysis and specifications of electrolytic chromium and manganese. Uses and properties. *Electro Metallurgical Co.*

697. Electron Microscope

20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

698. Electron Tubes

Catalog lists 67 types of electron tubes, describes them, gives general characteristics and maximum ratings. *Machlett*

699. Extruded Products

6-page folder covering extruded products. Diagrams of UGINE-Sejournet hot extrusion process. Alloys which may be successfully extruded. *Babcock & Wilcox*

700. Ferro-Alloys

32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

701. Filters

32-page booklet on filters, mixers, pumps and tanks for liquid processing. *Alasop Engineering*

702. Firebrick

28-page bulletin R-34 on properties and characteristics of 5 kinds of firebrick. Typical applications. Tables of brick quantities for arches of different sizes and shapes. *Babcock & Wilcox, Refractories Div.*

703. Flame Hardening

20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

704. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. *Waukegan Eng'g*

705. Fluoroscopy

12-page booklet on fluoroscopy for non-destructive internal inspection. Explains image amplifier. *Westinghouse Electric, Industrial X-Ray Dept.*

706. Forging Hammers

24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

707. Forging Machinery

32-page book No. 165 on design of dies for upsetting forging machines also includes machines, representative parts, tables of decimal equivalents and areas of circles. *Ajax Mfg. Co.*

708. Forgings

Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U.S. Steel*

709. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

710. Forgings

8-page booklet, "What Is a Forging?", on how forging idea originated and grew, how forgings are made and importance of forgings in modern products. *Drop Forging Assoc.*

711. Forming

86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling needed. *Yoder*

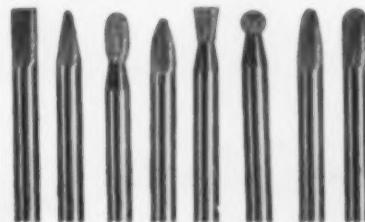
712. Forming

Contract forming catalog on complete contract facilities. Draw forming equip-

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For the toughest metal-cutting jobs, for cutting abrasive materials and metals too hard for High-Speed steel tools, Martindale Carbide Burs are the answer. They are precision ground from solid carbide and each tooth lapped to provide cooler cutting and longer life.

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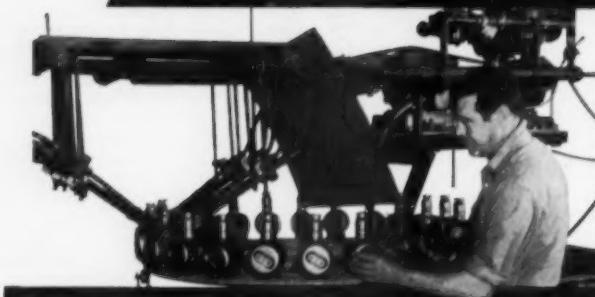


This is the trade mark of Brochu and Hass of Grand Rapids, Michigan

— one of the more successful manufacturers in the field of forming and assembling stampings in steel, brass and aluminum for automotive, household appliance and specialty hardware manufacturers.



These two complete reference manuals for low temperature silver brazing and fluxing are available upon request. Send for either one or both.



An efficient production schedule such as Brochu and Hass developed for this stamped oil reservoir assembly (an important component of an automotive hydraulic pump system) depends upon good, consistent performance of equipment, flux and brazing alloy.

After much experimentation, Brochu and Hass selected Silvaloy preformed silver brazing alloy rings and APW Black Flux "to insure perfect, strong joints and to avoid 'leakers' and costly re-brazing." With these materials, their specially built machine is capable of completing 300 to 400 units per hour.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call the Silvaloy Distributor in your area for information or technical assistance. ★ ★ ★ ★ ★ ★ ★ ★

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ment and conventional equipment. Cyril Bath Co.

713. Furnace Belts

New 42-page booklet on alloy steel belts for continuous high-temperature furnaces. Belt selection guide. Wickwire Spencer Steel Div.

714. Furnace Charging

12-page brochure on eight models of charging machines for heating and melting furnaces. Salem-Brosius

715. Furnace Supplies

8-page catalog on accessories to melting furnaces including linings, silicon-carbide base blocks, burners, blowers, pots and so on. Lindberg Engineering

716. Furnaces

44-page Catalog 112, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. C. I. Hayes

717. Furnaces

Bulletin 435 on furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. W. S. Rockwell

718. Furnaces

New catalog on standard and special furnaces and ovens to 3000° F. L & L Mfg. Co.

719. Furnaces

Brochures on pot furnaces, nitriding, austempering, and martempering and salt baths. A. F. Holden

720. Furnaces

Bulletin on electric heat treating furnaces describes five series and accessories. Lucifer Furnaces

721. Furnaces

Data on custom-built furnaces. Industrial Furnace Div., Martin Mfg. Co.

722. Furnaces

Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. Harper Electric Furnace

723. Furnaces

New vacuum furnace bulletin. National Research Corp.

724. Furnaces

High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. Carl-Mayer Corp.

725. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. Electric Furnace Co.

726. Gamma Radiography

16-page booklet on gamma isotope radiography includes isotopes used, uses, equipment. Budd Co.

727. Gamma Ray Sources

24-page booklet on portable gamma ray projectors, using cobalt 60, cesium 137, iridium 192. Operation and construction features. Metal & Thermit Corp.

728. Gas Purifiers

Folder on 6 gas purifiers and indicators for the catalytic purification, hydrogenation and oxidation of gases. Baker & Co.

729. Gear Tester

New bulletins on testing machines for roll testing of spur, worm, spiral and bevel gears. Geo. Scherr Co.

730. Gold Plating

Folder on salts for bright gold plating. Equipment needed. Sel-Rez

731. Graphite

20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. Great Lakes Carbon

732. Hard Surfacing

40-page hard facing manual tells what metals can be hard faced, how to select right hard facing material, lists step-by-step procedures and industrial applications. Haynes Stellite

733. Hardening Tool Steels

4-page bulletin on complete line of hydrazine furnaces. Diagrams, specifications and performance data on preheat and high speed furnaces. Lindberg Engineering

734. Hardness Conversion Tables

Celluloid card, 2 1/4 x 4 1/4 in., gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Sclerometer hardness values and corresponding tensile strengths of steels. International Nickel

735. Hardness Numbers

Pocket-size table of Brinell hardness numbers incorporating other tabular information. Steel City Testing

736. Hardness Tester

Bulletin on Brinell tester with test head for deep and offset testing. King Tester Co.

737. Hardness Tester

Bulletin on Impresor portable hardness tester for aluminum, aluminum alloys and soft metals. Barber-Colman

738. Hardness Tester

Data on hardness testing sclerometer with equivalent Brinell and Rockwell C numbers. Shore Instrument

739. Hardness Tester

Bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. Gries Industries, Inc.

740. Hardness Testers

20-page book on hardness testing by Rockwell method. Clark Instrument

741. Hardness Testers

20-page bulletin on models, applications and how to use superficial hardness testers. Wilson Mechanical Instrument

742. Hardness Testers

Folder on portable hardness testers for testing of various sizes, shapes and types of metal. Newage International

743. Heat Resistant Alloy

10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. Rolled Alloys

744. Heat Resistant Castings

16-page bulletin on design, foundry practice and applications. Electro-Alloys

745. Heat Treating

20-page catalog on the Homocarb method with Microcarb atmosphere control for heat treatment of steel. Leeds & Northrup

746. Heat Treating

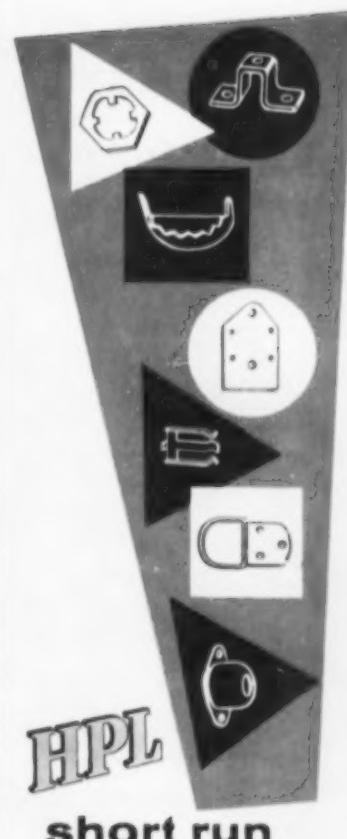
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. Young Bros.

747. Heat Treating

New edition of 73-page vest pocket data book on heat treating. Charts, tables, diagrams and factual data. Sunbeam Corp.

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Loose leaf data sheets on heat treating oils, salts, carburizing compounds. Park Chemical



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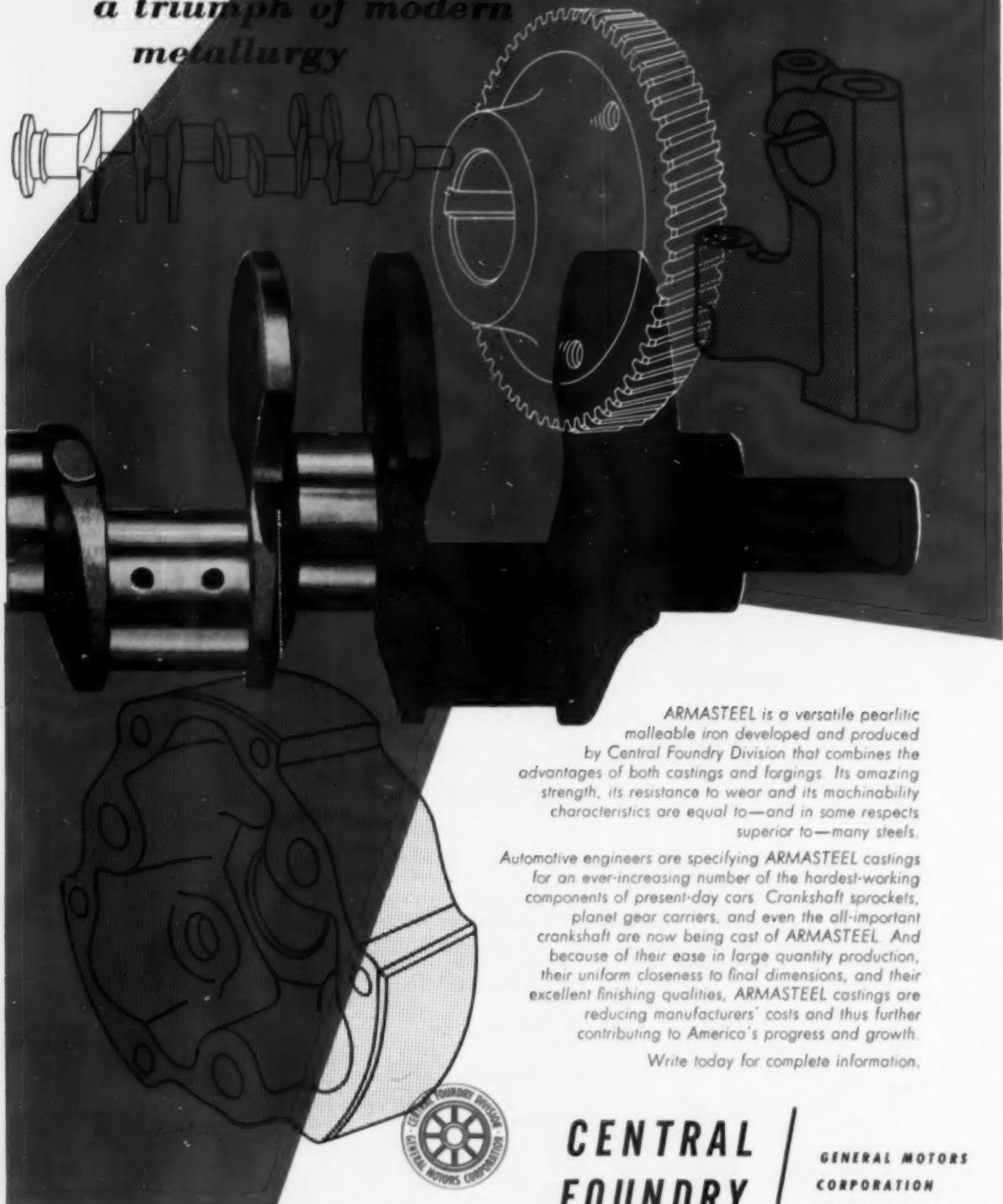
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749. Heat Treating

16-page booklet on cost accounting for heat treating. *Metal Treating Institute*

750. Heat Treating

Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

751. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

752. Heat Treating Belts

Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

753. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

754. Heat Treating Fixtures

32-page Catalog G-10 covers heat and corrosion resistant fabricated alloy products. Includes furnace muffle, trays, fixtures, retorts, pit-type furnace equipment, salt bath equipment, pickling and plating equipment. *Rolock, Inc.*

755. Heat Treating Fixtures

12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

756. Heat Treating Fixtures

Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

757. Heat Treating Furnaces

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

758. Heat Treating Furnaces

12-page booklet on various heat treating furnaces contains chronology of advances. *Holcroft*

759. Heat Treating Pots

Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

760. Heat Treating Supplies

Data sheets on carburizing, hardening, tempering, nitriding salts, metal cleaning and rust prevention materials. *Heatbath Corp.*

761. Heating Elements

24-page booklet on elements for electric furnaces and kilns includes technical data, uses, physical and electrical specifications. *Norton*

762. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

763. Heliare Welding

Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde*

764. High Alloy Castings

16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

765. High-Alloy Fabrication

4-page bulletin on high-alloy assemblies for chemical, petroleum, food, petrochemical, pharmaceutical and other process industries. *General Alloys*

766. High-Strength Bronze

12-page booklet on telnic bronze with high strength, high hardness, good machinability, age hardenability, corrosion resistance. *Chase Brass*

767. High Speed Steel

Folder on Electrite Double Six M-2 XL tungsten-molybdenum high speed steel

containing alloy sulphides for improved machinability and increased tool life. *Latrobe Steel Co.*

768. High-Strength Steel

48-page book on T-1 steel, its properties and applications. *U.S. Steel*

769. High-Strength Steels

48-page booklet on applications of seven nickel-copper high-strength low-alloy steels. *International Nickel Co.*

770. High-Strength Steel

66-page catalog on Mayari® steel. Applications which take advantage of its wear and corrosion resistance. *Bethlehem Steel*

771. High-Temperature Alloy

14-page bulletin on Udiment 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica Drop Forge and Tool*

772. High-Temperature Castings

16-page manual on heat and corrosion resisting castings. Principles of alloy composition, their properties and limitations, stabilizing influences and heat treatment. *Michigan-Standard Alloy Casting Co.*

773. High-Temperature Steels

87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U.S. Steel*

774. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

775. Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

776. Immersion Heating

4-page bulletin H-11 on correct selection, sizing and installation of equipment for immersion heating. *Eclipse Fuel Eng.*

777. Induction Heaters

8-page bulletin on new electronic induction heaters. Specifications for four models. Special features. *General Electric*

778. Induction Heaters

Bulletin on low-frequency induction heating describes units for brass, copper, titanium, steel, forgings, light metal extrusion presses. *Magnethermic*

779. Induction Heating

60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

780. Induction Heating

12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

781. Induction Melting

16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and non-ferrous metals. *Ajax Electrothermic*

782. Induction Melting

8-page reprint R-50 on recent development of the coreless line frequency induction melting furnace in European foundries. *Ajax Engineering*

783. Industrial Heating

New booklet on process heating operations for light metals. *Michigan Oven Co.*

784. Industrial Ovens

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New 12-page booklet on magnetic particle inspection, fluorescent penetrant, Stresscoat and other forms of nondestructive inspection. Magnaflux Corp.

786. Instrument Panels

New 16-page booklet gives specifications of instrument and control panels. Wiring and tubing illustrated. Bailey Meter Co.

787. Instruments

20-page bulletin containing series of articles on inductronic instruments. Performance, applications and ranges of sensitivity of amplifier and its accessories. Weston Electrical Instrument

788. Instruments

Folder gives examples of custom-made instrument cubicles and panels. Minneapolis-Honeywell Regulator

789. Investment Casting

12-page brochure on the process, shapes which may be cast, tolerances, assembly savings. Investment Casting Co.

790. Iron Powders

32-page book on design and powder metallurgy for iron powders. Tables, graphs of properties. Antara Products Div.

791. Laboratory Equipment

4-page catalog on Photoprocessor for processing all research and analytical photographic emulsions. Features and advantages. Jarrell-Ash

792. Laboratory Equipment

20-page catalog of apparatus for chromatography and electrophoresis including balances, colorimeter, densitometer, spectrophotometers. Harshaw Scientific.

793. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. Marshall Products

794. Laboratory Furnace

Bulletin 1016 on single and dual tube furnaces for combustion analysis. Sentry

795. Leaded Steel

8-page booklet on production of lead treated steels, their advantages and case histories of their use. Copperweld Steel

796. Leak Stopper

Data on teflon seal for leak stopping and prevention of future leaks. Tru-Seal Div., Flick-Reedy Corp.

797. Low-Alloy Steel

60-page book on high-strength low-alloy steel, properties, fabrication and uses. U.S. Steel

798. Low-Temperature Properties

48-page bibliography of characteristics of steels at low temperature covers 1904 to June 1953. Inco

799. Lubricant

Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. Alpha Corp.

800. Lubricant

Bulletin 425 on colloidal dispersions for use in metal casting. Best formulas for achieving high lubricity and wetting action. Acheson Colloids

801. Lubricants

8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. Grafo Colloids

802. Machining Copper

32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. American Brass

803. Machining Magnesium

64-page book discusses the various

machining operations, machinability, coolants for magnesium. Dow Chemical

804. Machining Stainless

16-page booklet on drilling, tapping, threading, turning, broaching, spiling, reaming. Machinability tables. Cutting speed tables. Crucible

805. Magnesium

42-page booklet on wrought forms of magnesium. Includes 31 tables. White Metal Rolling & Stamping

806. Magnesium Alloys

Loose-leaf folder of data and tables on chemical specifications, properties, extrusion, machining operations. Brooks and Perkins

807. Magnesium Extrusions

36-page bulletin gives values of moment of inertia, section modulus and radius of gyration of bars, tubing, angles, channels, tees, zees and other sections. Dow Chemical

808. Magnesium-Zirconium

10-page reprint on an investigation of zirconium chloride, zirconium fluoride, 40% zirconium-magnesium material for making magnesium-zirconium alloys. Titanium Alloy Mfg. Div.

809. Malleable Castings

Continuing series of information bulletins covering latest techniques and practices in modern malleable casting. Malleable Founders' Society

810. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. Martindale Electric

811. Microhardness Tester

Bulletin describes the Renton micro-hardness tester. Torsion Balance Co.

812. Microscopes

22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. Brusich & Lomb

813. Microscopes

Catalog on metallograph and several models of microscopes. United Scientific

814. Microscopes

New brochure SB 36 on Cycloptic stereoscopic microscope. American Optical

815. Molybdenum

24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. Sylvania Electric

816. Mo-Fe Castings

Bulletins 1 and 2 on molybdenum iron castings give advantages of molybdenum in these castings. Climax Molybdenum

817. Nickel Alloy

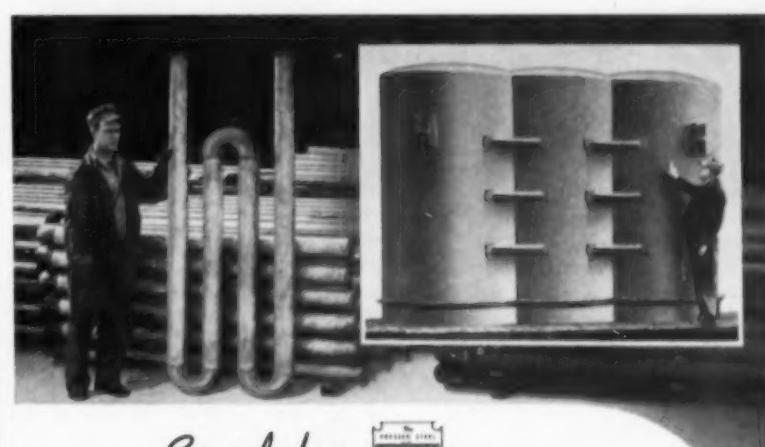
12-page booklet on Hastelloy Alloy R-235, vacuum-melted wrought alloy containing aluminum and titanium. Haynes Stellite Co.

818. Nickel Alloys

Wall chart gives engineering properties of nickel alloy wire, rod and strip. Includes Monel, Inconel, Incoloy and nickel-clad copper. Alloy Metal Wire Co.

819. Nickel Chromium Steels

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Rokide spray coatings help solve many high temperature and wear problems

WITH the rapid increase in modern high temperature applications there has been a corresponding increase in demands for resistant materials. Norton ROKIDE spray coatings are meeting such demands with great success. These hard, adherent crystalline refractory oxides offer many important advantages. For example:

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ROKIDE Coatings vs. Stainless Steel

Analyses of Norton ROKIDE spray coatings and of stainless steel reveal interesting comparisons. While less dense than the bare steel, the ROKIDE coatings are very much harder, have considerably higher melting points and are very much lower in thermal conductivity and thermal expansion.

Proof

There are three Norton ROKIDE coatings: ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia. Thoroughly proved in such critical applications as reaction motors, as well as in AEC projects, the value of these coatings to a broad range of more conventional applications is obvious.

Applications

The versatility and adaptability of ROKIDE coatings are evident in the fol-

lowing list of applications, actual and suggested:

Baffle plates . . . bearing surfaces . . . mechanical seals . . . feed rolls . . . metal treads . . . thermal barriers . . . reflection coatings . . . coatings for exhaust ports, duct linings, ladles and crucibles . . . insulation for copper busbars, circuit breaker components, thermocouple wires and tubes, large and small electronic equipment . . . protection for nozzles, valve plugs, piston heads, pump shafts, gas turbine parts, etc.

Although ROKIDE coatings are most commonly applied to metals they are effective on other materials, such as ceramics and certain plastics. Thicknesses of the coatings generally range from .005" to .05".

Other Norton Electric Furnace Materials

are products made of CRYSTOLON* silicon carbide (including ROKIDE "C" coating for graphite parts and CRYSTOLON "N" monolithic shapes), ALUNDUM* fused alumina, MAGNORITE* magnesium oxide, NORBIDE* boron carbide and Fused Stabilized Zirconia. These high-melting materials are also the basic ingredients of the famous Norton R's — refractories engineered and prescribed for the widest range of uses.

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characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

820. Nickel Plating

10-page paper on nickel plating process describes plating solution and operating conditions, make-up and control of solutions, analysis and properties. *Sel-Rex Precious Metals*

821. Nickel Plating

20-page instruction manual on bright nickel plating by the nickel-lume process. Bath preparation, converting existing baths, solution maintenance and purification. *Hanson-Van Winkle-Munning Superior Tube*

822. Nickel Tubing

New 20-page catalog gives properties and compositions of 13 analyses of nickel and nickel alloy tubing. Selection guide. *Superior Tube*

823. Nitriding

Data on process for nitriding stainless steel. *Standard Steel Treating*

824. Nondestructive Inspection

8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection and its uses. *Sperry Products*

825. Nondestructive Testing

Data on new nondestructive thickness tester. *Unit Process Assemblies*

826. Nondestructive Testing

8-page bulletin on equipment for non-destructive testing of bars, rods, tubing. *Magnetic Analysis*

827. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

828. Nonferrous Forgings

34-page booklet on brass, bronze and aluminum forgings. How they are made, composition of alloys, tolerances. *Mueller Brass*

829. Nonflammable Rust Preventive

Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

830. Oil Quenching

Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

831. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

832. Openhearts

Brochure on modern openhearth design and construction. *Loftus*

833. Ovens

New 16-page catalog on techniques used in process heating systems. Methods combining radiation and convection. *Jensen Specialties*

834. Oxygen Analysis

4-page bulletin on new oxygen sampling and recording equipment for open-hearth waste gases. *Leeds & Northrup*

835. Phosphate Coating

12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

836. Pickling

80-page book, "Efficient Pickling", covers all variables of process. Many charts and tables. *American Chemical Paint*

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837. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

838. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

839. Post-Weld Heat Treatment

8-page bulletin TR-543 demonstrates the need for post-weld heat treatment of air hardening alloys. *Babcock & Wilcox*

840. Powder Metallurgy

4-page folder presents extensive powder metallurgy bibliography for 1954 and 1955. *Harper Electric Furnace Corp.*

841. Powdered Metals

Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc*

842. Powdered Metals

Bulletin 800-B on pre-alloyed iron powders with varied chromium-nickel contents. *Metal Hydrides*

843. Powdered Metals

Booklet tells how things are made of powdered metals, applications and future possibilities. *Stokes*

844. Precision Casting

12-page book tells when to use precision castings, tolerances, how castings are made. *Alexander Saunders*

845. Precision Casting

8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

846. Precision Castings

12-page booklet gives data on casting design, size of castings, quality control, for precision castings of brass, bronze and aluminum alloys. *Atlantic Casting and Engineering*

847. Pressure Switch

Specification S1011-1 on new industrial gas pressure switch for use on multiple burner gas installations. Chief features. *Minneapolis-Honeywell Regulator*

848. Processing Equipment

Folder on rolling mills, slitting lines and accessory equipment. *Stanat*

849. Pyrometers

12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

850. Quenching Oil

Technical bulletin on quenching oil and accelerators to provide deeper hardening. *Park Chemical*

851. Quenching Oil

10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

852. Radiant Heat

Bulletin HD-740R describes and illustrates construction of radiant heat elements and shows how they are installed in furnaces. *Hevi Duty*

853. Radiography

16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

854. Radiography

26-page brochure on very high voltage equipment for radiography and how it is used. *High Voltage Engineering*

855. Recirculating Furnace

Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment*

856. Refractories

12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

857. Refractories

24-page booklet on how refractory grain is produced. Chemical and physical characteristics, sizes available, applications. *Norton*

858. Refractories

8-page catalog of super refractory shapes, tubes, insulators for use to 3000° F. *Morganite*

859. Resistance Welding

56-page catalog of resistance welding products, accessories and materials. Selection of alloys and electrode materials. *Weldaloy Products Co.*

860. Rhodium Plating

Data on properties, thicknesses required, costs, operation, applications. *Technic*

861. Roll Formed Shapes

24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

862. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

863. Salt Baths

32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

864. Salt Baths

Bulletin 800 on air-driven molten salt pump. Advantages of pump. Performance data. *Ajax Electric*

865. Salt Baths

Reprints 161 and 162 on new advances in hot salt quenching and salt bath quenching of gears. *Ajax Electric*

866. Saw Blades

Selector for hand or power blades tells which blade to use for various alloys and shapes. *Henry Danson*

867. Saws

Catalog C-53 describes 35 models of metalcutting saws. *Armstrong-Blum*

868. Silver Brazing

Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes, *Handy & Harman*

869. Silver Plating

8-page paper on bright silver plating process covers solution maintenance and operating conditions. *Sel-Rex Precious Metals*

870. Sintered Carbides

24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

871. Sodium

40-page booklet on handling metallic sodium gives typical sodium using processes, equipment installation, recommendations for pumping and instrumentation. *U.S. Industrial Chemicals*

872. Solvent Cleaning

16-page booklet on how to use solvent detergents for removing carbon, grease, dirt, paint. *Oakite Products*

873. Spark Testing

20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

874. Specimen

Article on practical system for preparing (Continued on p. 48-A)

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Specialized HEAT-RESISTING ALLOY

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- Insulating Properties Required?

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Table of Products and Uses

	Page		Page
Castables			
B&W Kaocrete-32 Special High Temperature Service—To 3200 F	7	B&W Kromecast Chrome-base Castable for Resistance to Attack of Slag and Other Reactive Products— To 3100 F	12
B&W Kaocast High Temperature, General Purpose Use— To 3000 F	8-9	B&W Hydrochrome Chrome-base Castable for Resistance to Attack of Slag and Other Reactive Products— To 2800 F	12
B&W Kaocrete-A General Purpose Use—To 2700 F	10-11	Insulating Concrete-Mixes	
B&W Kaocrete-B For Ease of Plastering in General Purpose Use—To 2300 F	10-11	B&W Kaolite-20 • Kaolite-20-Gun B&W Kaolite-22 • Kaolite-22-Gun For Castable Convenience Plus Insulating Effect	13
B&W Kaocrete-D For Extra Strength and Abrasion Resistance— To 2500 F	10-11		

SAW MILLS REFRACTORY PRODUCTS: B&W Allul Firebrick • B&W 80 Firebrick
• B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables,
Plasters and Mortars • B&W Silicon Carbide



(Continued from page 47)
ing metallurgical specimens, in July issue of "Metal Digest". Buehler

875. Spectrograph

8-page booklet on optical emission, direct reading spectrographs for production control and research. *Applied Research Labs.*

876. Spectrograph

24-page booklet on Echelle spectrographs. Advantages. Type of work produced. *Bausch & Lomb*

877. Spectrograph

New 8-page catalog on Spec-Lab. Performance and applications of three models. *Jarrell-Ash*

878. Spectrometer

8-page Bulletin 44 on direct reading spectrometers. Operation and construction. *Baird Associates*

879. Speed Recorders

Data Sheet ND46-27(1) on Speedomax G recorders for measurement of rotational and linear speeds and about the tachometer generators used with them. *Leeds & Northrup*

880. Spring Steels

Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold rolled and bright annealed sizes in stock. *Sandvik Steel*

881. Stainless Castings

11 reference sheets for major stainless casting alloys give compositions, properties, resistance to corrosive solutions, machinability, heat treatment, weldability. *Cooper Alloy*

882. Stainless Fastenings

20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

883. Stainless Steel

44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

884. Stainless Steel

Data sheet on Type 301 gives physical properties, corrosion and oxidation resistance, mechanical properties. *Allegheny Ludlum*

885. Stainless Steel

32-page book on corrosion resistance of stainless steels. 18 tables on tests in acid, neutral and alkaline solutions. *International Nickel*

886. Steel

Bulletins on hot work steel and Type

420 stainless give forging, annealing and hardening characteristics. *Firth Sterling*

887. Steel

256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel compositions, hardness numbers conversions. *Ryerson*

888. Steel 52100

Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

889. Steel Treating

Bulletin on flame hardening, induction hardening, carbonitriding, nitriding, liquid carburizing, Chapmanizing. *Lake-side Steel Improvement*

890. Steel Tubing

48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

891. Steelmaking

Beautifully illustrated brochure on steelmaking, annealing, hot rolling, finishing. *Rotary Electric Steel*

892. Strain Gages

8-page article on performance of SR-4 high temperature strain gages and how to apply them in "Testing Topics". *Baldwin-Lima-Hamilton Corp.*

893. Sub-Zero Equipment

12-page catalog of chilling machines and temperature testing units. *Cincinnati Sub-Zero Products*

894. Swaging Machines

16-page catalog on complete line of swaging equipment contains data on rotary swaging process and its applications. *Fenn Mfg. Co.*

895. Temperature Conversion

16-page temperature conversion booklet and electromotive force of thermocouple alloys in absolute millivolts. *Wheelco*

896. Temperature Measurement

8-page catalog 175 on optical, micro-optical, radiation, immersion and surface pyrometers. *Pyrometer Instrument Co.*

897. Test Equipment

Catalog R-36A on complete line of testing equipment, including all industrial electronic and electrical equipment. *Weston Electrical Instrument*

898. Test Specimens

Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

899. Testing Equipment

Details and specifications of complete line of base plates in new illustrated booklet. *Lake Shore, Inc.*

900. Testing Machines

28-page catalog on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

901. Textured Metal

16-page booklet on advantages and applications of textured metal. *Rigidized Metals*

902. Thermocouple Alloys

20-page booklet on chromel-alumel alloys gives sizes, temperature-millivolt equivalents, standards, applications. *Hoskins Mfg. Co.*

903. Thermocouple Restorer

New catalog R-27 on device for renewing proper electrical conductivity through thermocouples and thermocouple circuits. *Peerless Electric Co.*

904. Thermocouple Wire

Bulletin on thermocouple wire and thermocouple extension wire lists sizes, metals, insulations. *Claud S. Gordon*

905. Thermocouples

New 14-page bulletin No. 5 on miniature protected thermocouples. Calibrations and temperature ranges available, immersion lengths and other data. *Thermo Electric*

906. Thermocouples

32-page file book on pyrometer accessories. Selection of thermocouple and protective tube. *West Instrument Corp.*

907. Tin News

Interesting monthly report covers important current developments in the production, marketing and use of tin. *Malayan Tin Bureau*

908. Titanium

8-page booklet on corrosion resistance of titanium. Table of ratings of titanium compared with stainless and aluminum in various mediums. *Mellory Sharon*

909. Titanium and Zirconium

16-page bulletin, "The Hydromet Process", on titanium and zirconium metals and hydrides, and other metallurgical hydrides. *Metal Hydrides*

910. Tool and Die Steels

26-page book on six oil and air hardening steels for high-production tools and dies. Many uses illustrated. *Bethlehem Steel*

911. Tool Steel

Wall chart showing more than 300

BLAZING
THE
HEAT
TREAT-
WITH

HOLCROFT

Shaker hearth hardening
furnace in foreground uses
Holcroft refractory rails for
hearth support.

LET'S TALK ABOUT REFRACTORY RAILS

With the current shortage of nickel, furnace manufacturers are looking for ways to replace or conserve this scarce commodity. It is interesting to note that Holcroft tackled this same problem during World War II when a nickel shortage also faced the industry.

In 1945 we designed and installed a pusher tray gas atmosphere furnace that used refractory skid rails instead of the nickel chrome alloys used at that time. Since then we have expanded their use to many other comparable applications so that now there is positive proof that properly designed installations of refractory skid rails last much longer, under similar conditions, than those made from nickel alloys. Replacements have been negligible—performance has been superior—material costs have been lower—and a marked decrease in wear on work carriers has been noted.

Yes, today a nickel shortage still exists—but Holcroft offers a job-proven answer, not only for the rails but for other vital parts of a heat treat furnace as well. You can bank on Holcroft's engineering leadership and experience—the kind that saves not only nickel—but dollars, too! Write for information.

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CMP
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COLD ROLLED STRIP STEEL
can feed this automated line
at the high speed require-
ment of the operation.

Costly new equipment is not always the sole answer to production cost problems. Often the wrong raw material may completely nullify expected savings from heavy capital investments in modern machinery.

Consider the case of one manufacturer who installed expensive new forming equipment but was unable to up production to the expected level. Material being formed was cold rolled strip 4" x .060", AISI 1050 steel processed to standard gauge tolerances (.0567" to .0632").

When **CMP** Precision Cold Rolled Strip Steel ordered to a 60% gauge restriction (.0567" to .0613") was furnished, production immediately moved up to the rated capacity of the machines and has remained there.

In addition to increased production, because of the minimization of down time, an incidental and important benefit was the increase in yield per **CMP** ton processed because rejections and out of tolerance parts were eliminated.

Careful consideration of **CMP** Restricted Specification Cold Rolled Strip Steel alternatives on the same careful basis given to your equipment investment, may point the way to similar, or larger pay-offs.

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CMP Products—low carbon, electro zinc coated, high carbon, tempered spring steel, stainless and alloy.

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CMP STRIP PROVIDES
MAXIMUM NUMBER OF
PRECISION PARTS AND
HELPS ELIMINATE COSTLY
HUMAN ERRORS

varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

912. Tool Steel

Data sheets on high speed, hot work, air, oil and water hardening tool steels, alloy steels, machinery steels, stainless steels, welding rods. *Crucible Steel*

913. Tool Steels

Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

914. Tool Steels

Data on air-hardening hot work die steel for forging. *Ziv Steel & Wire Co.*

915. Tubes

Bulletin TB-412 on electric-resistance-welded carbon steel tubes for heat exchangers and condensers. *Babcock & Wilcox*

916. Tubing

Data Memorandum No. 4 on large diameter thinwall tubing in seamless and Weldrawn grades. Applications. *Superior Tube*

917. Tubing

32-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

918. Tubing

12-page catalog on cold drawn, mechanical, capillary, nickel and nickel alloy tubing. *J. Bishop & Co. Platinum Works*.

919. Tukon Tester

12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

920. Tumbling

8-page booklet on precision tumbling, a controlled-motion honing process for parts which could not previously be finished by tumbling. *BMT Mfg. Corp.*

921. Tungsten Alloy

Data on properties and uses of 95% tungsten alloy, balance nickel and copper. *Firth Sterling*

922. Ultrasonic Cleaning

Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

923. Ultrasonic Cleaning

Folder on principles and methods of metal cleaning by application of ultrasonic energy. *Detrex*

924. Ultrasonic Inspection

Ultrasonic Inspection Newsletter, No. 2, contains article on immersion inspection of wing spars for jet fighters. *Sperry Products*

SEPTEMBER, 1956

571	598	625	652	679	706	733	760	787	814	841	868	895	922
572	599	626	653	680	707	734	761	788	815	842	869	896	923
573	600	627	654	681	708	735	762	789	816	843	870	897	924
574	601	628	655	682	709	736	763	790	817	844	871	898	925
575	602	629	656	683	710	737	764	791	818	845	872	899	926
576	603	630	657	684	711	738	765	792	819	846	873	900	927
577	604	631	658	685	712	739	766	793	820	847	874	901	928
578	605	632	659	686	713	740	767	794	821	848	875	902	929
579	606	633	660	687	714	741	768	795	822	849	876	903	930
580	607	634	661	688	715	742	769	796	823	850	877	904	931
581	608	635	662	689	716	743	770	797	824	851	878	905	932
582	609	636	663	690	717	744	771	798	825	852	879	906	933
583	610	637	664	691	718	745	772	799	826	853	880	907	934
584	611	638	665	692	719	746	773	800	827	854	881	908	935
585	612	639	666	693	720	747	774	801	828	855	882	909	936
586	613	640	667	694	721	748	775	802	829	856	883	910	937
587	614	641	668	695	722	749	776	803	830	857	884	911	938
588	615	642	669	696	723	750	777	804	831	858	885	912	939
589	616	643	670	697	724	751	778	805	832	859	886	913	940
590	617	644	671	698	725	752	779	806	833	860	887	914	941
591	618	645	672	699	726	753	780	807	834	861	888	915	942
592	619	646	673	700	727	754	781	808	835	862	889	916	943
593	620	647	674	701	728	755	782	809	836	863	890	917	944
594	621	648	675	702	729	756	783	810	837	864	891	918	945
595	622	649	676	703	730	757	784	811	838	865	892	919	
596	623	650	677	704	731	758	785	812	839	866	893	920	
597	624	651	678	705	732	759	786	813	840	867	894	921	

925. Ultrasonic Testing

Data folder describes instruments using ultrasonics for various tests—immerscope, "B" scan and flaw recorder. *Curtiss-Wright*

926. Vacuum Alloys

Folder on vacuum melted cobalt, ferrous and nickel base alloys. Quality control. *Cannon-Muskegon Corp.*

599. Product File

More than 30 new product developments, more than 700 booklets, bulletins and engineering data sheets are presented in a 16-page file reference in *Application and Equipment News*. Reprinting the product and literature items that have appeared in *Metal Progress* during the third quarter of 1956, this handy summary of what's new in metals, design applications, processing, fabrication and equipment may be used throughout the year.

933. Welding

52-page catalog on gases, welding and cutting equipment and accessories for job shops, maintenance departments and other users of light gas and arc equipment. *Air Reduction Sales*

934. Welding Copper

24-page booklet on oxyacetylene, carbon-arc and metal-arc welding techniques for copper and copper alloys. *Revere*

935. Welding Electrodes

84-page pocket-size booklet describes characteristics, coating, sizes of various electrodes and compares them with standard designations and other electrode brand names. *Harnischfeger*

936. Welding Equipment

Folder on equipment for welding and cutting by the acetylene process. Regulators, torches and other equipment. *Dockson Corp.*

937. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

938. Welding Magnesium

Various welding processes for magnesium, stress relief and recommended procedures. *Brooks & Perkins*

939. Welding Rods

Folder on eight welding rods for steel, cast iron, brass and bronze. Techniques for gas welding. *Metal & Thermit*

940. Wire Cloth

Bulletin 113 on wire cloth in various alloys, in bulk or specially fabricated parts. *Cambridge Wire Cloth*

941. Wire Straightening

20-page brochure on wire straightening and cutting machines, wire reels, chafing and deburring machines. New air clutch described. *Lewis Machine Co.*

942. X-Ray

12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

943. X-Ray Equipment

12-page booklet on 250-kv constant potential X-ray equipment for internal inspection. Advantages, design features. *Westinghouse Electric*

944. X-Ray Supplies

Bulletin on X-ray films and chemicals for radiography. *Anasco*

945. Zinc and Cadmium Plate

Technical data sheets on use of Luster-on salts for zinc and cadmium plating. *Chemical Corp.*

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Please have literature circled at the left sent to me.

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Students should write direct to manufacturers.

Our business is staked on it

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THIS IS OUR LABORATORY REPORT on one customer's order for Alloymet nickel base pig and shot* for stainless steel production.

It gives a complete analysis of each heat included in the total order. A notarized report such as this travels with every order of Alloymet alloys.

These alloys of certified analysis are available at approximately 5% over the cost of nickel alloy scrap.

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* Alloymet available in a complete range of nickel chrome, nickel iron and nickel copper analyses.



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DAVENPORT, IOWA

Steel Company
Pennsylvania

Shipped June 2, 1956

Gentlemen:
Sample No. See Below Representing 30,000 lb. Nat. Ni-Cr. 1332
has been carefully tested and we report our analysis as follows:

Heat #	Gross	Tare	Net	Ni	Cr	C	Si	Mn	N
B-1-10	1338	42	1296	60.49	14.98	.27	.57	.65	—
B-1-11	1282	46	1236	60.38	14.87	.25	.51	.60	—
B-1-12	1364	44	1320	60.75	14.83	.28	.58	.63	—
B-1-13	1286	46	1240	60.24	14.95	.24	.55	.59	—
B-1-14	1298	43	1255	60.94	14.97	.19	.52	.60	—
B-1-15	1398	42	1316	60.87	14.82	.24	.57	.63	—
B-1-16	1308	40	1268	60.91	14.88	.20	.55	.58	—
B-1-17	1232	46	1186	60.73	15.01	.27	.51	.57	—
B-1-18	1320	46	1274	60.41	15.10	.20	.53	.55	—
B-1-19	1296	44	1252	60.27	15.03	.23	.50	.59	—
B-1-20	1332	48	1284	60.75	14.90	.24	.56	.58	—
B-1-21	1290	44	1246	60.34	14.88	.20	.55	.56	—
B-1-22	1350	46	1304	60.41	14.85	.27	.51	.57	—
B-1-23	1298	43	1255	60.07	14.95	.29	.50	.60	—
B-1-24	1282	46	1236	60.86	15.15	.24	.56	.61	—
B-1-25	1308	40	1268	59.97	14.78	.25	.54	.59	—
B-1-26	1364	44	1320	60.41	14.88	.23	.52	.58	—
B-1-27	1338	42	1296	60.32	14.90	.26	.54	.67	—
B-1-28	1296	44	1252	60.27	14.88	.20	.58	.69	—
B-1-29	1332	40	1305	60.34	14.95	.20	.50	.53	—
B-1-30	1350	45	1246	60.49	15.21	.19	.51	.51	—
B-1-31	1286	40	1253	60.24	14.88	.23	.51	.51	—
B-1-32	1298	45	1253	60.24	14.88	.23	.51	.51	—

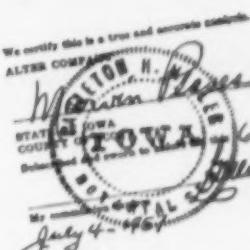
* Spectrographic Analysis

(Continued on Page 2)

Analyzed by _____

Checked by _____

Signed _____



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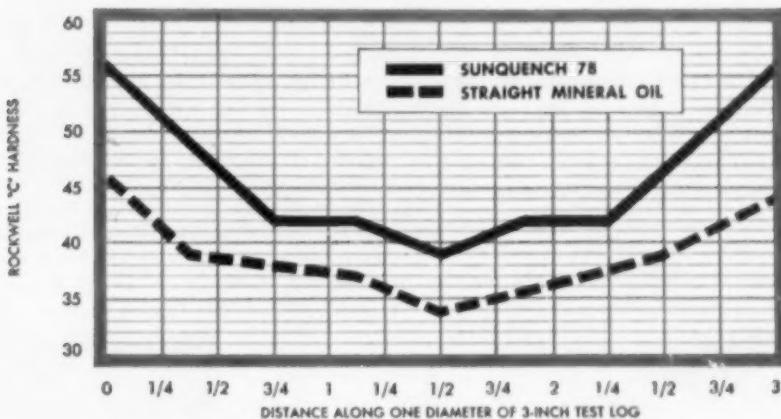
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NEW! FAST! LONG LASTING!...



A new high-speed quenching oil
with an extra-long service life

....SUNQUENCH 78



Three-inch test logs of AISI 4140 were quenched in both SUNQUENCH 78 and a conventional quenching oil. The graph shows the results.

SUNQUENCH 78* was developed for those tough quenching jobs where a conventional quenching oil can't give you satisfactory results. For example:

Easily distorted parts can be satisfactorily quenched in SUNQUENCH 78. It rapidly wets out all surfaces and produces a uniform quenching action.

Baskets of tightly packed parts can be quenched more uniformly because of the efficient cooling action of SUNQUENCH 78.

Baths with inadequate agitation frequently can't develop full hardness with conventional quenching oils. Here again, SUNQUENCH 78 is the answer.

Steels of low hardenability, which have been substituted for more expensive alloy steels, develop maximum hardness and strength when they are quenched in SUNQUENCH 78.

The long service life of SUNQUENCH 78 is just as important as its high-speed quenching action. Special inhibitors give SUNQUENCH 78 an exceptionally high thermal and oxidation stability. Even at abnormally high quenching-bath temperatures, SUNQUENCH 78 has very little tendency to thicken-up or form cooler-clogging sludge.

For more information on new SUNQUENCH 78, and other Sun Quenching Oils, see your Sun representative or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-9.



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IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

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brass and bronze forgings help insure

dependability and lasting jewel-like

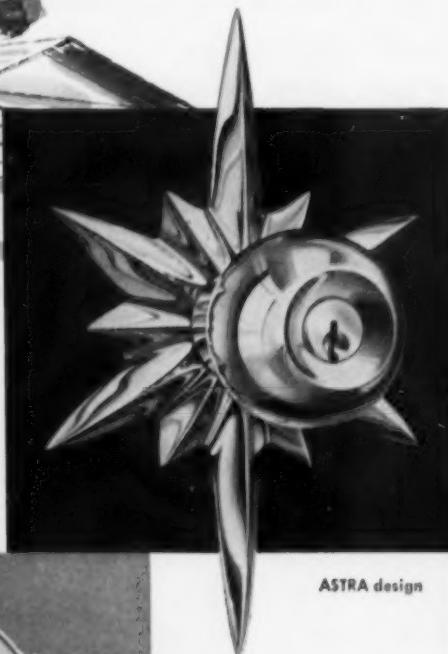
finish of distinctive

SCHLAGE locks

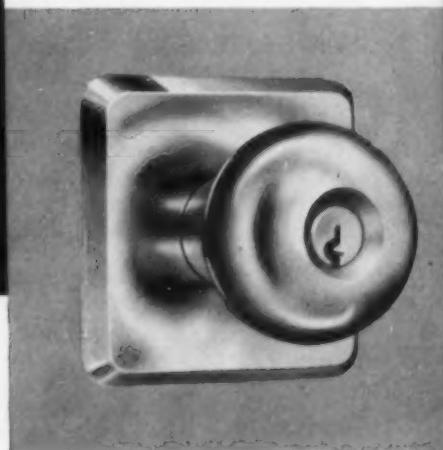
Smart styling, handsome appearance and durability have been neatly combined by the Schlage Lock Company of San Francisco in their line of lock designs for residential and commercial use. Many important parts of these lock sets are brass and bronze forgings made by the Mueller Brass Co. The beautiful natural color, corrosion resistance, and inherent dependability of these forgings make them ideal for this purpose. In addition, the high degree of surface smoothness makes possible an exceptionally lustrous finish as well as a perfect plating surface when required. Then, too, the use of forgings has reduced costs, cut finishing time and greatly re-

duced the number of rejects when compared to the sand castings that were formerly used.

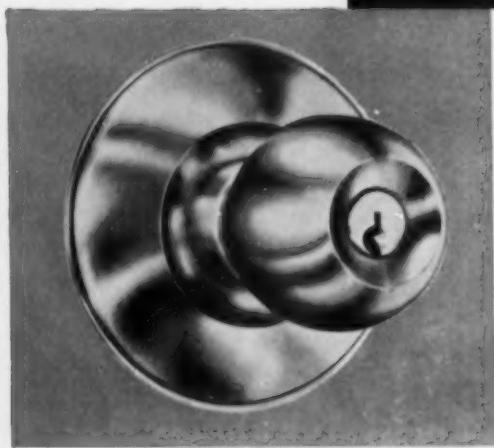
Whether you manufacture decorative hardware where finish is of prime importance or rugged assemblies that must stand up to bruising everyday punishment, it will pay you to investigate Mueller Brass Co. forgings. Strong, long wearing brass, bronze or aluminum parts, forged to your exact specifications under exacting statistical quality control standards can help you reduce costs, improve performance, and give you a better looking product. Write for our engineering manual (No. H-58565) . . . or call in one of our engineers to investigate possible forging applications in your products.



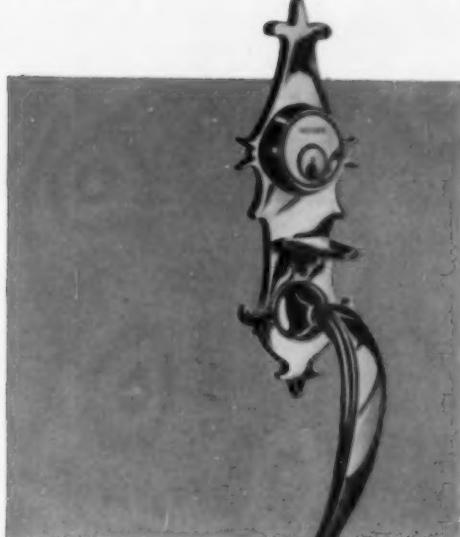
ASTRA design



MONARCH design



MERCURY design



WAVERLY design



PANTHEON design

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Mueller Brass Co. Forgings
Engineering Manual H-58565

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563

600 Series Bearing Alloys
Engineering Manual FM-3000

Copper Base Alloys in Rod Form
Engineering Manual FM-3010

**METALS
AND ALLOYS
REVIEW**



by FRANK M. LEVY

Vice-President and Director of Research

Last week one of our sales engineers was at the home office and we were talking about one of his customers in the East who manufactures milling machines which are being used for milling aircraft spars. We are supplying gibs, slide bars and wear strips to this company made of our "600" series bearing metal in rectangular rod form. The material formerly used was aluminum bronze* cast bars which they could only obtain in 36" lengths. Their engineering department estimates that costs have been reduced 50% on this component. Machining time has been reduced and impregnation of porous castings has been eliminated.

Our sales representative was curious about my experience with "600" in other applications such as this. Oddly enough, our own plant has been a pretty good proving ground. In our extrusion department, for example, we have gotten exceptionally good service from slides made of "600" and used on the die heads which are subject to pressure and extremely rough usage.

Bob Irwin of our forging department reports that the "600" strips he has used for lining the ways of our big forging presses have proved far superior to the bronzes which were original equipment. The bronze strips squashed out after protracted running. More important, the "600" strips last 10 times longer before replacement is necessary.

In our copper tube fabricating department we have a lot of automatic equipment for the production of formed tube shapes like toes and eills used in the plumbing industry. On one of the tube benders, there was no provision made for replacing worn forming slides. Our Maintenance Department reworked the machine using "600" strips as replaceable forming slide inserts. The bender is now a far more efficient machine. Because of the long life of "600", downtime on this machine has been practically eliminated.

While we were talking about these uses in our own plant, it brought to mind some other instances where the exceptionally good wearing properties of "600" have been established. A Cincinnati lathe manufacturer uses "600" in the form of counter sunk hex-headed screws on wearing strips used on lathe carriages. When the strip wears to the retaining screw the ways will not be scratched.

According to their own records, all other materials which they had tested proved unsatisfactory for the job. Another maker of precision lathes and milling machines found that after a year of exhaustive tests, the "600" metal that was used as nuts on compound slide screws outlasted competitive metals at an approximate ratio of 3 to 1 at an estimated saving of 30%.

Sliding surfaces on all kinds of machinery have different wear characteristics, as you have undoubtedly found. If you have any problems involving gibs, slide bars or wear strips that are proving troublesome, why not drop me a line or send a part print and we'll be glad to study it and make the proper recommendations.

*We manufacture & grade of wrought aluminum bronze.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

concerned with metal fatigue . . .

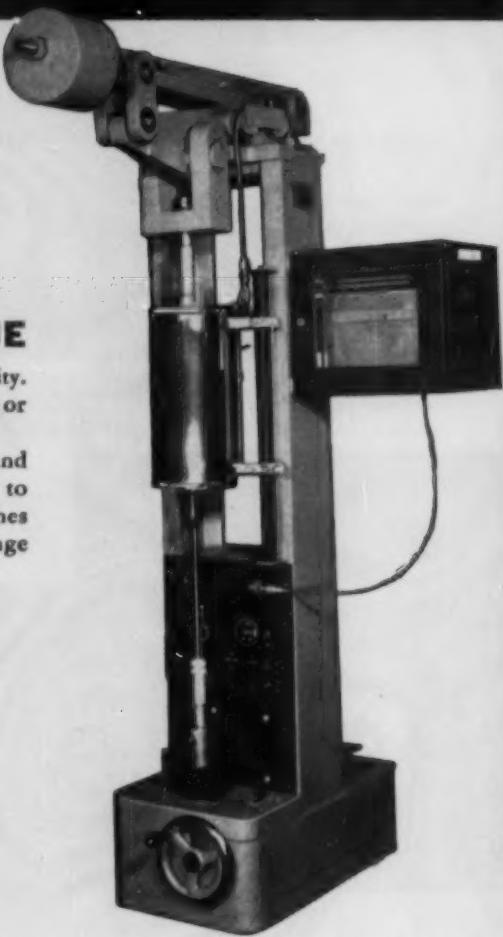
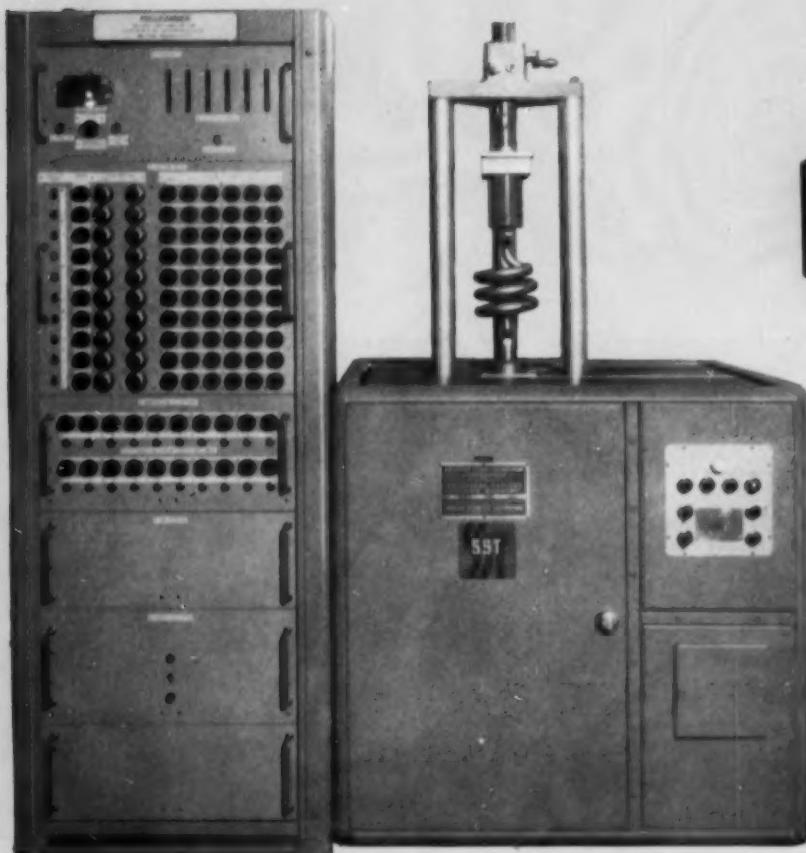
. . . see this new Baldwin testing

Never before have engineers been called upon to know so much about the characteristics of so many materials under so many varying conditions. To help you meet the challenge, Baldwin offers outstanding new testing equipment specifically designed for today's requirements.

CREEP TESTING MACHINE

Lever type, for long-time creep tests, has 20,000 pounds capacity. Load applied by dead weights. Accuracy within $\frac{1}{2}\%$ of load or 0.1% of capacity.

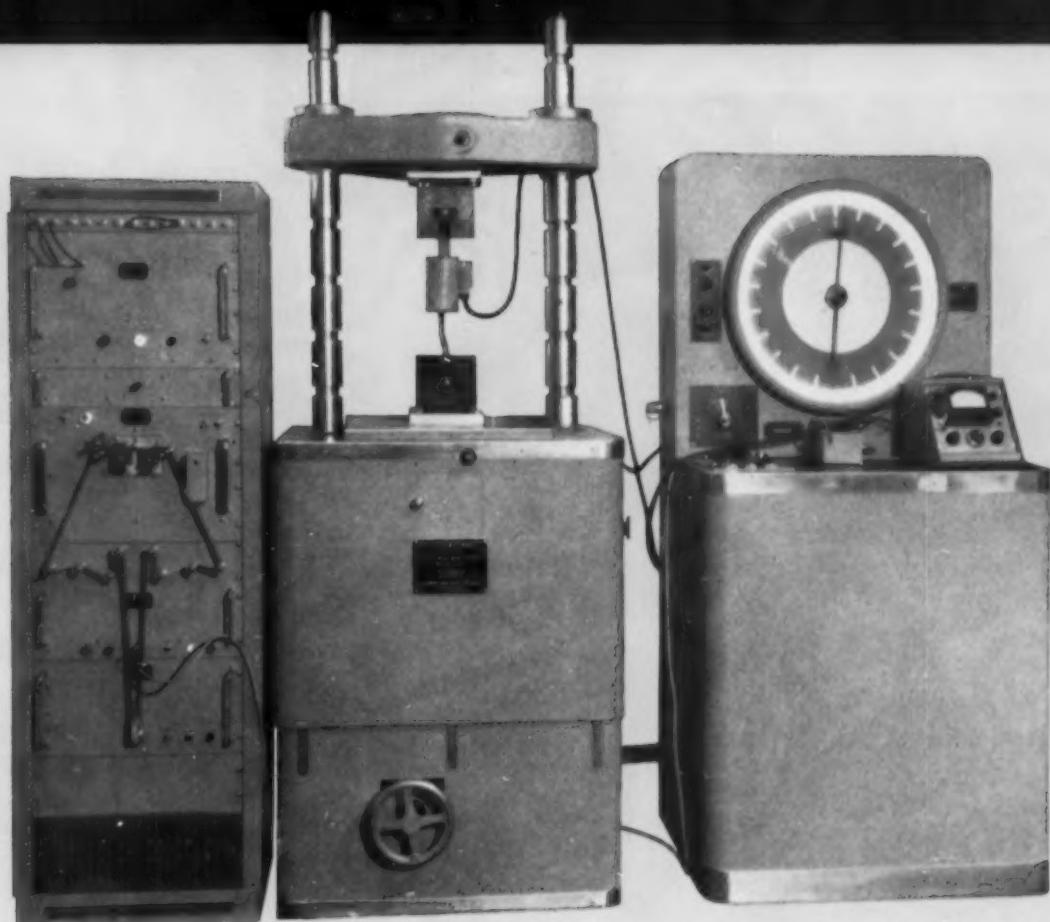
Spring block machines for short-time creep rupture tests and for automatic creep relaxation tests (capacities from 1,000 to 20,000 pounds) are also available. All Baldwin creep machines are built on the same basic frame, so as your requirements change you can "convert" by changing head and accessories.



AUTOMATIC LOAD PROGRAMMING, FATIGUE TESTING

Baldwin-Sonntag universal fatigue machines can now be equipped with "adjustable-while-running" oscillators so that dynamic as well as static loads can be changed without stopping tests. The Baldwin programmer has been developed to automatically control these loads. As many as 10 load levels can be selected in sequences: increasing, increasing-decreasing or random.

or creep . . . or cycling effects? equipment in action at ASM show



SR-4® UNIVERSAL TESTING MACHINE OPERATED FROM STRAIN GAGE SIGNALS

This system represents idealized automation in testing of materials and structures. Strain gage signals from actual field tests are stored on

magnetic tape and used in the laboratory to automatically control the testing machine and reproduce service conditions.

Be sure to see these new machines in operation in booth 2104 at the ASM Show, Cleveland, Ohio. And for illustrated bulletins, write Department 1724, Electronics and Instrumentation Division, BLH Corporation, Waltham 54, Mass.

HEADQUARTERS FOR THE BEST IN TESTING EQUIPMENT

ELECTRONICS & INSTRUMENTATION DIVISION
BALDWIN-LIMA-HAMILTON



Gulf Sales Engineer T. F. Irving checks with Frank Buettner, heat treating foreman, on the results of hardness obtained in heat treating bolts at Lamson and Sessions' plant in Cleveland, Ohio.



*Why one of the world's largest
nut and bolt manufacturers*

*-Lamson and Sessions—
has been a long-time user of*

Gulf Super-Quench

The metallurgists at Lamson and Sessions discovered that with Gulf Super-Quench they were able to achieve deeper, more uniform hardness without cracking or distortion and virtually eliminate rejections. Furthermore, it made possible the use of steels which previously could not be hardened to their specification.

Lamson and Sessions was also impressed with the ability of this outstanding quenching oil to retain its quenching

power indefinitely with only normal make-up and that there was no need for additive replenishment.

Let a Gulf Sales Engineer help you discover profitable opportunities to use Gulf Super-Quench in your plant. Consult the yellow pages of the telephone directory for the number of your local Gulf office.

Clip and send the coupon for your copy of our informative brochure on this quality product.



Gulf Oil Corporation • Gulf Refining Company
1822 Gulf Building, Pittsburgh 30, Pa.

MP

Gentlemen:

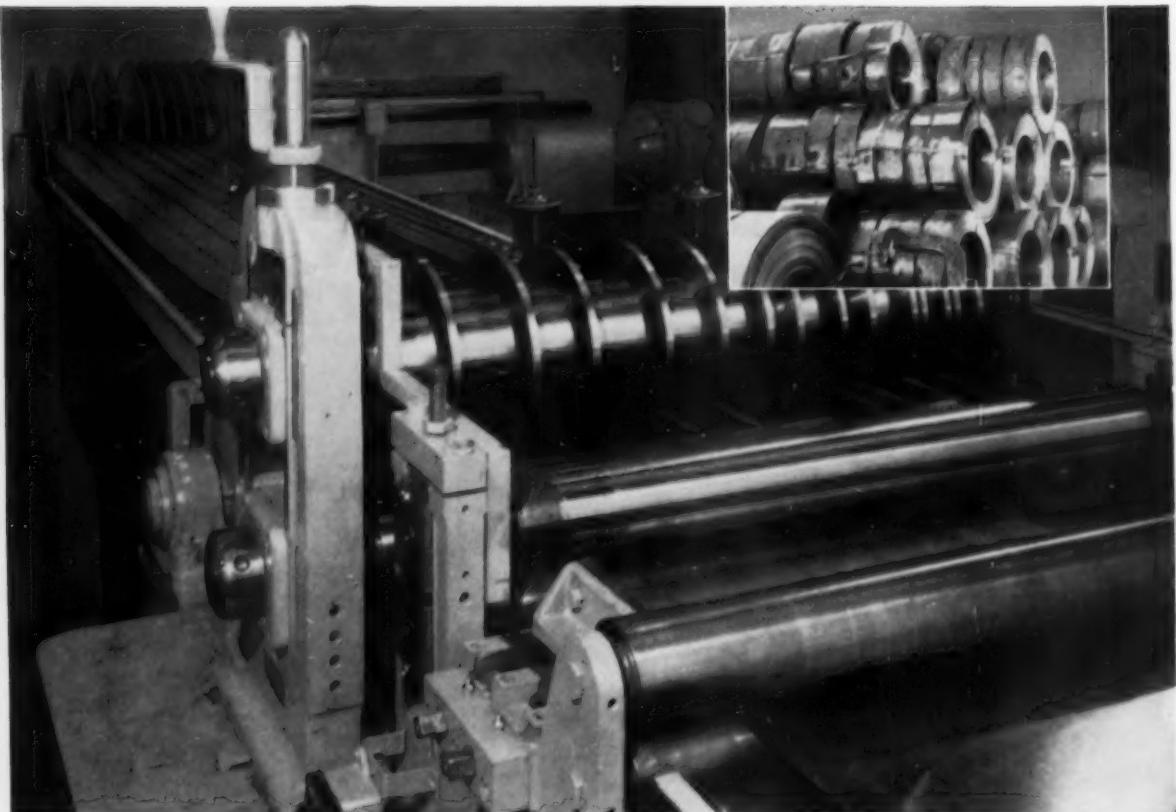
Please send me, without obligation, a copy of your 24-page brochure dealing with the application and advantages of Gulf Super-Quench.

Name _____

Title _____

Company _____

Address _____



...these things and others, too, a Yoder Slitter can do for you...

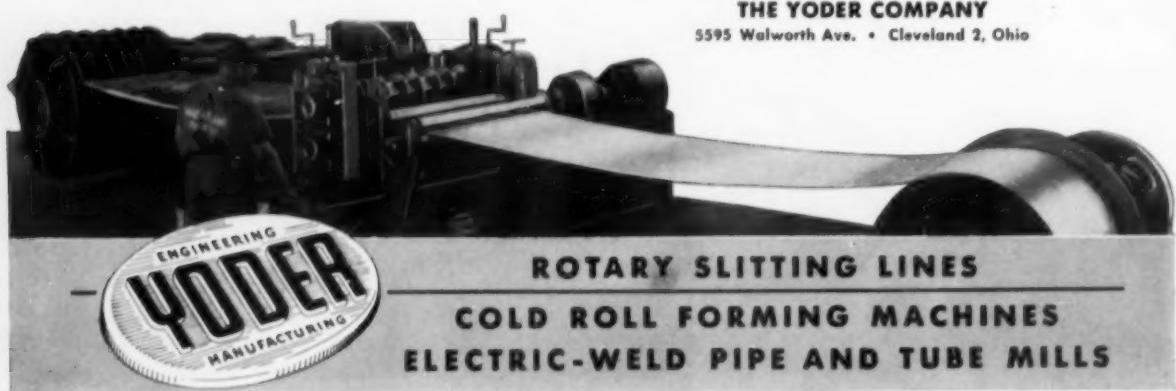
By doing your own slitting, you may easily save \$12,000 or more per year in slitting cost alone, on requirements as low as 100 tons per month.

But don't make the mistake of thinking this is the only saving or advantage enjoyed. Many owners realize equally important savings by being able to buy standard width coils competitively, from more numerous sources of supply—wherever they can get the best price and quality. Much quicker deliveries are also obtainable in this way.

Inventory requirements, too, are greatly reduced and production planning simplified because, from a relatively small stock of mill-width coils or sheets, you can meet expected and unexpected needs for slit strands in a few hours.

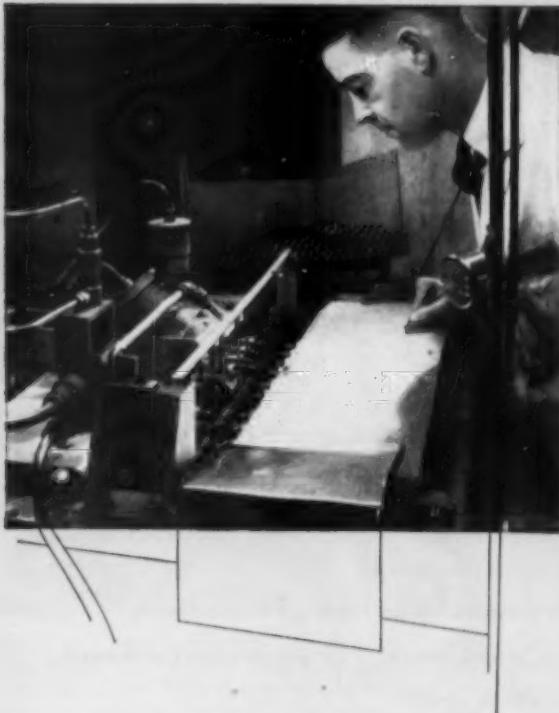
Send for the Yoder Slitter Book—a comprehensive text on the mechanics and economics of slitters and slitting line operation, with time studies, cost analyses and other valuable data. It's yours for the asking.

THE YODER COMPANY
5595 Walworth Ave. • Cleveland 2, Ohio



ROTARY SLITTING LINES
COLD ROLL FORMING MACHINES
ELECTRIC-WELD PIPE AND TUBE MILLS

'dag' dispersions... a touch does so much!



Tool-life increased 60 times

In an unusual multiple-spindle drilling operation, a machine-tool firm found that straight cutting-oil did not give satisfactory performance. Drills constantly had to be resharpened after sinking about 50 holes.

However, when a 1:300 dilution of a 'dag' dispersion of colloidal molybdenum disulfide in oil was tried, tool life before resharpening was extended to 3,000 holes!

This result is typical of the production improvements which can be realized through the use of this outstanding new high-pressure lubricant. Whatever your machining operation, it is likely that molybdenum disulfide can help. And Acheson Colloids' service engineers can give you the benefit of their experience in its application. Why not get in touch with your nearby Acheson representative? Meanwhile, write for your free copy of Bulletin No. 424.



ACHESON COLLOIDS COMPANY

PORT HURON, MICHIGAN

... also Acheson Colloids Ltd., London, England

ACHESON COLLOIDAL DISPERSIONS:
Graphite • Molybdenum Disulfide • Zinc Oxide
Mica and other solids

'dag' is a registered trademark of Acheson Industries, Inc.

Acheson Colloids Company, Dept. C-9
Port Huron, Michigan

Yes, I want to get your free catalog on 'dag'
dispersions for use in Industrial Lubricants.

Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____





THAT one is no good!

Wouldn't you like to be *that* sure about duds in your own production? Nondestructive radiography (either x-ray or gamma ray) could do it for you maybe.

Anything you buy or sell which needs "seeing into" is fair game for this versatile inspection method . . . weldments, castings, assemblies, plastics, wood, metal . . . right across the board from paper-thin stuff to foot-thick steel.

If you need to spot hidden defects to keep a firm finger on quality control, we'll be glad to tell you what radiography can do for you.*

* There's probably a Picker District office near you (see local 'phone book). Or write Picker X-Ray Corporation, 25 South Broadway, White Plains, New York.

5 to 50 KV

Small as a filing cabinet, yet it will x-ray anything up to $\frac{1}{4}$ " thick aluminum. Self-contained, completely rayproof.



150 KV

Penetrates up to 1" steel and $5\frac{1}{2}$ " aluminum (more with screens). Stationary or mobile for "on-the-spot" x-raying.



250 KV portable

Rugged, lightweight 250 KV tubehead with separate remote power chassis. Will enter openings as small as 13" square.



RADIOGRAPHIC CABINETS

Rayproof enclosures obviate need for lead-lined rooms. Available with or without feeder tables.



260 KV crane or dolly

For heavy-duty inspection (up to 3" steel). Operating down to 60 KV, will x-ray a wide range of other materials.



GAMMA Sources, equipment, containers.

Panoramic, circumferential, and directional projectors using cesium, iridium or cobalt isotopes.



one source for everything in



radiography and fluoroscopy



Caterpillar Tractor Co. Metallurgist T. H. Spencer inspects final drive pinion for D9 crawler tractor weighing 28 tons. Severe loading of this large pinion requires a steel with high case and core hardenability. Several years ago

Caterpillar Tractor Co. found that simply by increasing the molybdenum content of AISI 8622 (to 0.30-0.40%), the desired properties were obtained at lower cost than was possible in any of the standard carburizing grades.

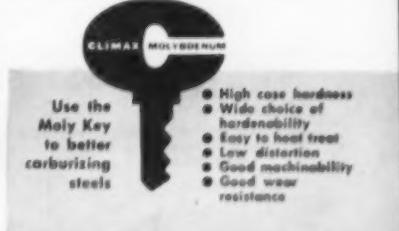
Caterpillar Tractor Co. improves case and core hardenability of carburizing steel by increasing molybdenum content

"Drive pinions in tractors must take very high torque loads," says T. H. Spencer, Metallurgist for Caterpillar Tractor Co. "AISI 8622 steel, which we had been using, couldn't give us the hard case and strong, tough core we needed in these heavy sections. Other standard carburizing steels with the requisite properties would have cost substantially more. We found, however, that we could achieve the desired surface and core properties by simply modifying AISI 8622 with a higher percentage of molybdenum. We have been using this composition for several years, and results have been excellent."

Caterpillar Tractor Co.'s experience shows how increasing molybdenum in a carburizing steel helped to solve a specific problem. Perhaps your product, too, can benefit by higher molybdenum content.

A technical article, "New Carburizing Steels for Critical Gearing", describes some recent investigations of higher-moly carburizing steels. For a reprint, write Climax Molybdenum Company, Dept. 5, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM



- High case hardness
- Wide choice of hardenability
- Easy to heat treat
- Low distortion
- Good machinability
- Good wear resistance

Time Tested

ADDRESSOGRAPH-MULTIGRAPH BUSINESS MACHINES

*are created with quality in mind
... that's why YOUNGSTOWN STEEL
is specified as a basic material*

It's apparent in many quality products you see every day: Perfection of manufacture starts with the basic material. And, with Addressograph-Multigraph, as with many other quality manufacturers, a basic material is Youngstown Steel—cold finished bars and cold rolled sheets.

Youngstown Cold Finished Bars have desirable uniformity and machineability. Injurious seams, cracks and other imperfections do not occur. Youngstown Cold Rolled Sheets have the right temper that makes them easier to form. That means fewer rejects and better fabricated products.

You are hours, dollars and energy ahead when you specify Youngstown. Get in touch with our nearest Youngstown District Sales Office for complete information.

Multigraph Multilith Offset Duplicator, one of many production machines for business records manufactured by Addressograph-Multigraph Corporation, Cleveland, Ohio.



Youngstown

**COLD FINISHED BARS
COLD ROLLED SHEETS**

THE YOUNGSTOWN SHEET AND TUBE COMPANY

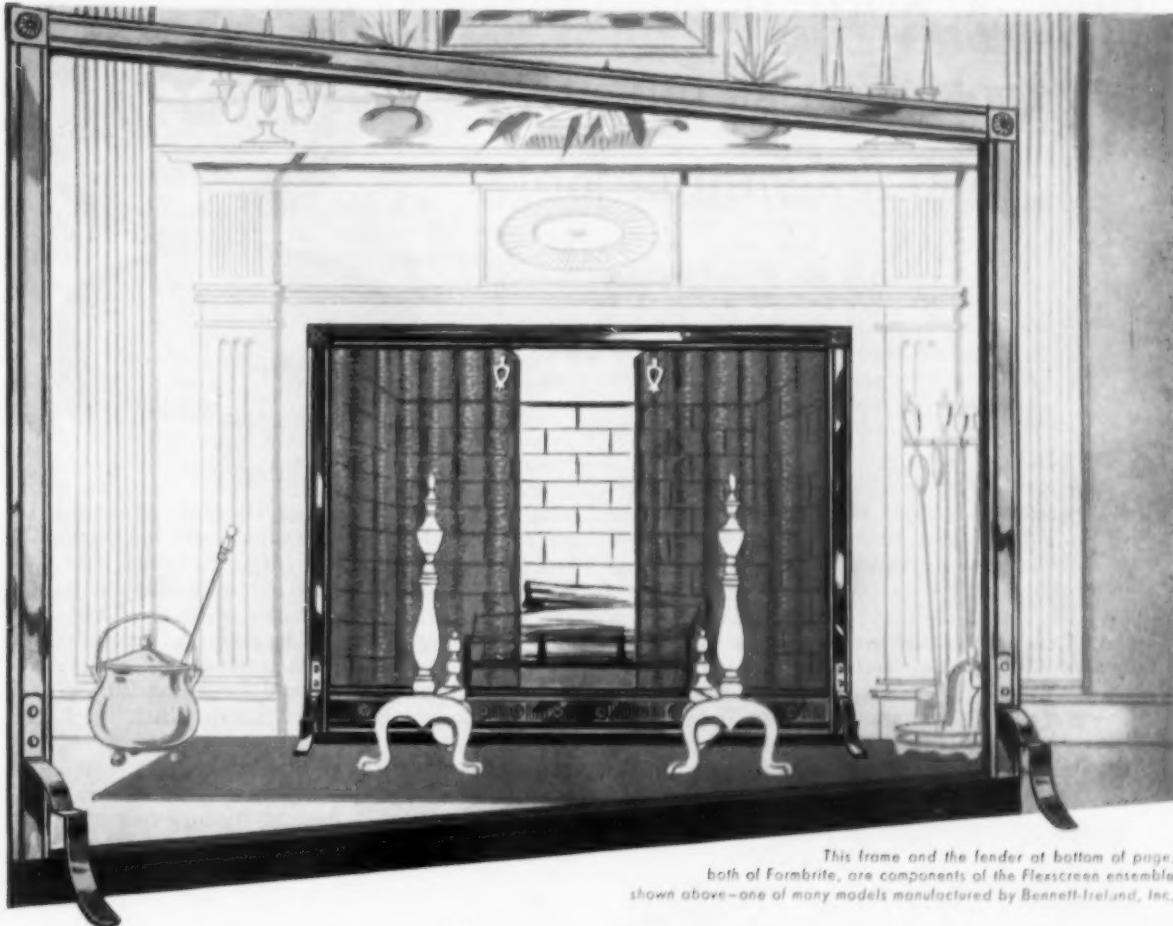
General Offices Youngstown, Ohio District Sales Offices in Principal Cities.

*Manufacturers of
Carbon, Alloy and Specialty Steel*

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT -
MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - WIRE - HOT ROLLED RODS - COKE -
TIN PLATE - ELECTROLYTIC TIN PLATE - BLACK PLATE - RAILROAD TRACK SPIKES - MINE ROOF BOLTS

Formbrite cuts polishing cost 50% for *Flexscreen*[®]

Bennett-Ireland, Inc., drops cutting operation completely, speeds buffing—finds Formbrite also gives a more attractive, scratch-resistant finish.



This frame and the fender at bottom of page, both of Formbrite, are components of the Flexscreen ensemble shown above—one of many models manufactured by Bennett-Ireland, Inc.

Bennett-Ireland, Inc., Norwich, N.Y., previously used ordinary drawing brass for hearth fenders, kerbs, and frames in their famous flexible-metal fireplace screen ensembles. In polishing, the production rate was 12 frames per hour for the cutting operation and 4.5 frames per hour in the buffing operation.

When Bennett-Ireland changed to Formbrite[®], they found they could drop the cutting operation completely. And Formbrite's superior fine-grain finish speeded the buffing rate to 6.8 frames per hour. Thus the unit polishing costs for

the frames were cut 50 per cent.

Bennett-Ireland also found that Formbrite forms readily with no rejections and that it resists scratching during forming and handling. The end result is a product with superior eye-appeal that will remain beautiful in the home through the years.

See for yourself: Formbrite is a premium product at a nonpremium price. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better still, ask about

a sample or a trial batch. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

*Reg. U.S. Pat. Off.

Formbrite
SUPERFINE-GRAIN DRAWING BRASS
an **ANACONDA**[®] product
made by
The American Brass Company

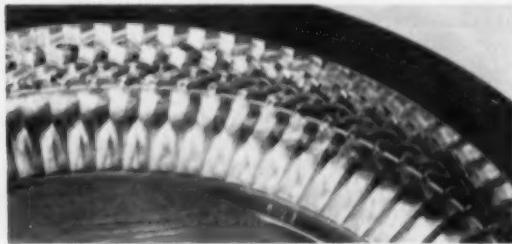
STEEL MACHINING CASE STUDY

How \$30 worth of steel plate
took the risk out of
a \$4000 machining job!

There's a quick, sure way to select exactly the right steel—whatever your particular application. Draw on the wide experience of Ryerson specialists who are working with hundreds of other steel users on similar problems every day. The right steel can make a big difference—can mean a better product, lower production costs—as the following case study illustrates.

THE PROBLEM—Central Mold & Machine Company of Akron contracted to make a chrome-plated mold for producing an exact duplicate, in miniature, of Firestone's new Supreme tubeless tire.

Only a very small piece of plate steel was needed for the job—but the steel had to be extraordinarily clean and sound. Hundreds of hours of machining time were to be "invested" in it and some of the tiny lands that formed the unusually intricate tread design were only .015 of an inch thick!



A close up of the mold for the 6" tire showing intricate machining with lands only .015" thick.

SOLUTION—Working with a Ryerson representative, Central Mold & Machine selected New E-Z-Cut plate for the job. Because this Ryerson leaded plate steel is remarkably clean and free of excessive stringers, even the finest lands of the mold were sharp and true. Because New E-Z-Cut machines as much as 30% faster than mild steel plate, the difficult machining job was completed in minimum time. And because New E-Z-Cut machines to a high finish and polishes readily, the mold was very satisfactorily prepared for plating, at low cost.

If a better quality free-machining plate had been available at any price it would have been used here because, at almost any price, the cost of the steel would be only a tiny fraction of the cost of the finished mold. New E-Z-Cut (approximately \$30.00 worth) was used because it took the steel risk out of a \$4000 machining job.

Whatever your steel problem, it will pay you to check with Ryerson specialists and draw on Ryerson stocks of highest quality, special purpose steels.



NEW E-Z-CUT PLATE VS. MILD STEEL A Machining Demonstration Booth 405—National Metal Exposition

The remarkable machinability of our New E-Z-Cut leaded plate steel will be demonstrated at the October National Metal Exposition in Cleveland. Don't miss it!

Flame cutting also demonstrated—Watch the actual burning of intricate steel shapes with electric eye equipment.

RYERSON STEEL

In stock: Carbon, alloy and stainless steel... bars, structurals, plates, sheets, tubing, reinforcing bars, machinery & tools, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI
CLEVELAND • DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Metal Progress

Volume 70, No. 3

September, 1956

The next 32 pages of this issue of Metal Progress are occupied by an outline — the barest outline — of the program of the 38th National Metal Congress and a listing of the 470 exhibitors in the National Metal Exposition. The Exposition has been limited only by the capacity of Cleveland's Public Auditorium and its seven exhibition areas. The Congress of American Society for Metals and the cooperating societies gives such a variety of technical fare that we have presented the meetings morning by morning and afternoon by afternoon, so the metals engineer may easily choose the topic of most interest to him at a given time.

The early birds will have Saturday and Sunday for a high-level discussion of creep and recovery culminating in a lecture by E. N. daC. Andrade, the leading British authority. Monday morning the American Welding Society will listen to the Adams Lecture. On Wednesday morning the Ⓣ's Campbell Memorial Lecture will be given by Charles S. Barrett on "Metallurgy at Low Temperatures"; and on Wednesday afternoon N. L. Mochel will deliver the Society for Non-destructive Testing's Mehl Honor Lecture.

An entirely new event, the "Awards Luncheon", will be held on Tuesday. After presentations of several awards, each recognizing some notable contributions to the metal industry, Charles M. White, chairman of the board of Republic Steel Corp. will talk briefly on our industry's engineering manpower problems and opportunities.

The Ⓣ Annual Banquet on Thursday evening

Charles M. White
Board Chairman
Republic Steel Corp.
Principal Speaker at
Awards Luncheon



will have as its principal speaker John R. Dunning, dean of engineering at Columbia University, whose knowledge of such things as atomic fission is matched only by his wit and urbanity.

Industrial Heating Equipment Assoc. will hold another of its notable conferences — this one on Tuesday morning, and the topic is Controlled Atmospheres and Their Control. Thursday will see an entirely new type of meeting, an Ⓣ Discussion Forum on Stamping Dies — no speakers, no papers, no preparation. Imagine! That same day at the Carter Hotel the Ⓣ is cooperating with the Atomic Energy Commission in a comprehensive discussion of "The Metal Thorium".

These are only some of the highlights of the Congress.

Friday the National Metal Congress will be host to all junior members of the Ⓣ attending colleges within bus-riding distance. At noon will be the Distinguished Service Luncheon where 25-year members will sit elbow to elbow with the youngsters who will carry on the metal industry in the future.

All this week, afternoon and evening, the National Metal Exposition will have its doors open to members of the cooperating societies and their guests. If past records from the registration desk can be relied upon, more than 50,000 such men will pass through the turnstiles.

Come to Cleveland in October and get some new ideas. Bring as many of your associates as necessary to attend all the interesting events. One good idea picked up during the week will repay the cost many times over!



John R. Dunning
Dean of Engineering
Columbia University
Principal Speaker at
⠁ Banquet

National Metal Congress

Cleveland, Oct. 6 through 12, 1956

American Society for Metals



Headquarters, Statler Hotel

Technical sessions, Monday through Friday morning
Seminar on Creep and Recovery, Saturday and Sunday
Educational Course on Residual Elements, Monday and Tuesday
Educational Course on Fatigue, Thursday
Discussion Forum on Dies, Thursday
Joint Conference with A.E.C. on Thorium, Thursday



American Institute of Mining and Metallurgical Engineers, Institute of Metals Division

Headquarters, Carter Hotel

Technical sessions, Monday through Wednesday
Symposium on Titanium, Tuesday



American Welding Society

Headquarters, Cleveland Hotel

Technical sessions, Monday afternoon through Friday morning
Educational Lectures, Tuesday and Wednesday afternoon
Plant tours, Wednesday and Thursday morning



Society for Nondestructive Testing

Headquarters, Hollenden Hotel

Educational sessions, Monday
Technical sessions, Tuesday through Thursday



Industrial Heating Equipment Association

(Jointly with ASM)

Technical sessions, Tuesday



Special Libraries Association, Metals Division

Headquarters, Manger Hotel

Technical sessions, Thursday
Field trips, Wednesday and Friday

Complete programs, grouped by days, shown on following pages

Saturday, Oct. 6, 1956

9:00 A.M. Statler Hotel

Seminar on Creep and Recovery

Defects and Recovery

By *J. Koehler*, University of Illinois

The Thermodynamics and Kinetics of Recovery

By *M. B. Beever*, Massachusetts Institute of Technology

Polygonization

By *W. R. Hibbard, Jr.*, General Electric Research Laboratories



2:00 P.M. Statler Hotel

Seminar on Creep and Recovery

Recovery of Electrical Resistivity

By *T. H. Blewitt*, Oak Ridge National Laboratories

Recovery of Mechanical Properties

By *E. C. W. Perryman*, Atomic Energy Establishment, Canada

Recovery of Internal Friction and Elastic Constants

By *A. S. Nowick*, Yale University

8:00 P.M. Statler Hotel

Seminar on Creep and Recovery

The Concept of Creep

By *E. N. daC. Andrade*, F.R.S., London, England

Sunday, Oct. 7, 1956

9:00 A.M. Statler Hotel

Seminar on Creep and Recovery

Theory of Creep

By *G. Schoeck*, Westinghouse Research Laboratories

The Role of the Boundary in Creep Phenomena

By *E. R. Parker* and *J. Washburn*, University of California

The Effect of Alloying Elements on Creep

By *J. C. Fisher*, General Electric Research Laboratories

2:00 P.M. Statler Hotel

Seminar on Creep and Recovery

The Spectrum of Activation Energies for Creep

By *J. E. Dorn*, University of California

Creep and Fracture

By *N. J. Grant*, Massachusetts Institute of Technology

Creep of Crystalline Non-Metals

By *J. B. Wachtman, Jr.*, National Bureau of Standards



Monday Morning,

9:00 A.M. Carter Hotel Session on Research in Progress



- 9:00 A.M. Carter Hotel
- Research Seminar – Embrittlement**
- Effect of Hydrogen on Alpha Titanium Alloys**
By G. A. Lenning, Titanium Metals Corp. of America, J. W. Spretnak, Ohio State University, and R. I. Jaffee, Battelle Memorial Institute
- Upper-Nose Temper Embrittlement of a Nickel-Chromium Steel**
By L. D. Jaffee and D. C. Buffum, Jet Propulsion Laboratory, California Institute of Technology
- On the Nature of Embrittlement Occurring While Tempering a Nickel-Chromium Alloy Steel**
By G. Bhat, Crucible Steel Co. of America, and J. F. Libsch, Lehigh University
- Observations on the Mechanical Properties of Hydrogenated Vanadium**
By B. W. Roberts and H. C. Rogers, General Electric Co.
- Effect of Small Amounts of Alloying Elements on the Ductility of Cast Molybdenum**
By L. E. Olds and G. W. P. Rengstorff, Battelle Memorial Institute

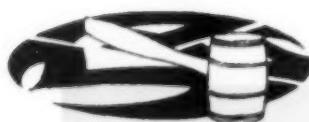
9:00 A.M. Hollenden Hotel Educational Session

- Welcome**
By Hamilton Migel, President, Society for Nondestructive Testing
- Orientation**
By D. T. O'Connor, Chairman, S.N.T. Educational Committee
- Sources of Defects Located by Nondestructive Testing**
By Carl E. Betz, Magnaflux Corp.
- Radiography**
By W. D. Kiehle, Eastman Kodak Co.
- Radiographic Film Interpretation**
By L. L. Johnson, Pratt & Whitney Aircraft
- Fluoroscopy**
By W. R. Hampe, Westinghouse Electric Corp.
- Penetrant Testing**
By Taber DeForest, Magnaflux Corp.
- Eddy Current Testing**
By G. O. McClurg, Magnaflux Corp.

9:30 A.M. Statler Hotel Session on Iron

- The Effect of Sub-Boundaries and Carbide Distribution on the Notch Toughness of an Ingot Iron**
By J. C. Danko and R. D. Stout, Lehigh University
- Notch Ductility of Malleable Irons**
By G. A. Sandoz, N. C. Howells, H. F. Bishop and W. S. Pellini, Naval Research Laboratory
- New Nodular Iron Process**
By Harry K. Ihrig, Allis-Chalmers Mfg. Co.
- The Deformation and Rupture of Gray Cast Iron**
By W. R. Clough, Electro Metallurgical Co., and M. E. Shank, Massachusetts Institute of Technology

Oct. 8, 1956



9:30 A.M. Statler Hotel

Session on Plastic Deformation

Slip, Twinning and Fracture in Single Crystals of Iron
By J. J. Cox, E. I. du Pont de Nemours and Co., G. T. Horne and R. F. Mehl, Carnegie Institute of Technology

Dynamic Biaxial Stress-Strain Characteristics of Aluminum and Mild Steel
By George Gerard and Ralph Papirno, New York University

Some Exploratory Observations of the Tensile Properties of Metals at Very Low Temperatures
By E. T. Wessel, Westinghouse Research Laboratories

Effect of Strain Rate and Temperature on the Plastic Deformation of High-Purity Aluminum
By T. A. Trozera, O. D. Sherby and J. E. Dorn, University of California



10:00 A.M. Cleveland Hotel

President's Welcome and Presentation of Awards

10:30 A.M. Cleveland Hotel

Adams Lecture

10:30 A.M. Statler Hotel

Educational Lecture Course on Effect of Residual Elements on the Properties of Metals

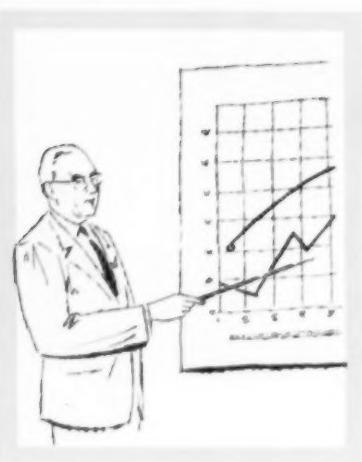
Fundamental Considerations
By E. R. Parker, University of California

12:00 M. Statler Hotel

Battelle Alumni Luncheon



Monday Afternoon



1:45 P.M. Hollenden Hotel

Educational Session

Magnetic Particle Inspection

By W. E. Thomas, Magnalux Corp.

Ultrasonic Testing, Contact Methods

By Ralph W. Frank, Sperry Products, Inc.

Ultrasonic Testing, Immersed Method

By J. B. Morgan, Aluminum Co. of America

Ultrasonic Testing, Resonance Method

By P. K. Block, Branson Instrument Co.

2:00 P.M. Statler Hotel

Educational Lecture Course Effect of Residual Elements on the Properties of Metals

Impurities in the Common Nonferrous
Metals

By F. N. Rhines, Carnegie Institute of
Technology

2:00 P.M. Statler Hotel

Session on Titanium

Relative High-Temperature Properties of the Hexagonal Close-Packed and Body- Centered Cubic Structures in Iodide Titanium

By John Lunsford and N. J. Grant, Massa-
chusetts Institute of Technology

The Influence of Alloying on the Elastic Modulus of Titanium Alloys

By W. H. Graft, D. W. Levinson and W.
Rostoker, Armour Research Foundation

A Study of the Air Contamination of Three Titanium Alloys

By J. E. Reynolds, H. R. Ogden and R.
I. Jaffee, Battelle Memorial Institute

Effect of Sulphur on the Properties of Ti- tanium and Titanium Alloys

By L. W. Berger, D. N. Williams and R. I.
Jaffee, Battelle Memorial Institute

Relationship Between Heat Treatment, Structure and Mechanical Properties of a Titanium Alloy Containing 4% Cr and 2% Mo

By A. W. Goldenstein and W. Rostoker,
Armour Research Foundation

2:00 P.M. Carter Hotel

Symposium on Nuclear Metallurgy

Theory and Mechanism of Radiation Effects
in Metals

By G. H. Vineyard, Brookhaven National
Laboratory

Irradiation Effects on Physical Metallurgical
Processes

By D. E. Thomas, Westinghouse Electric
Corp.

Irradiation Effects in Reactor Materials
By Douglas Billington, Oak Ridge National
Laboratory

2:00 P.M. Cleveland Hotel

Session on Inert-Arc Welding

Factors Affecting Melting Rate of Gas-
Shielded Metal-Arc Welding

By A. Lesnewich, Air Reduction Co., Inc.

Shielding Gases for Inert-Gas Welding
By W. H. Helmbrecht and G. W. Oyler,
Linde Air Products Co.

Inert-Gas Metal-Arc Welding of High-
Pressure Valves

By F. R. Zacheus, Air Reduction Sales, Inc.

and Evening, Oct. 8, 1956

2:00 P.M. Carter Hotel

Research Summaries — Mechanical Properties

Influence of Silicon and Aluminum on the Properties of Hot Rolled Steels
By R. H. Frazier, F. W. Boulger and C. H. Lorig, Battelle Memorial Institute

Creep of Polycrystalline Nickel
By J. Weertman and P. Shahinian, Naval Research Laboratory

Study of the Effect of Gases on the Melting, Casting and Working of Palladium
By R. H. Atkinson, International Nickel Co., Inc.

Effect of Mo, W and V on the High-Temperature Rupture Strength of Ferritic Steel
By A. E. Powers, General Electric Co.

Ti — 36% Al as a Base for High-Temperature Alloys
By J. B. McAndrew, Armour Research Foundation, and H. D. Kessler, Titanium Metals Corp. of America

High-Strength Zirconium Alloy—Zirconium Plus 4% Tin Plus 1.6% Molybdenum
By Walston Chubb, Battelle Memorial Institute

Creep of Single Crystals and Polycrystals of Aluminum, Lead and Tin
By C. D. Wiseman, O. D. Sherby and J. E. Dorn, University of California

Effect of Melting and Casting Atmospheres on the Stress-Rupture Properties of Cast Nickel-Based Alloys
By C. M. Hammond and R. A. Flinn, University of Michigan

Aging in Complex Commercial Nickel-Chromium Alloys Hardened With Titanium and Aluminum
By R. F. Wilde, General Motors Corp., and N. J. Grant, Massachusetts Institute of Technology

Effect of Orientation on the Plastic Deformation of Aluminum Single Crystals and Bicrystals
By R. S. Davis, R. L. Fleisher, J. D. Livingston and Bruce Chalmers, Harvard University

2:00 P.M. Cleveland Hotel

Session on Structures

Behavior of Welded Built-Up Beams Under Repeated Loads
By J. E. Stallmeyer, W. H. Munse and B. J. Goodal, University of Illinois

Welded Open-Web Expanded Beams
By M. Altfeldsch, B. R. Cooke and A. A. Toprac, University of Texas

Welded Reinforcement of Openings in Structural Steel Tension Members
By R. A. Hechtman and D. D. Vasarhelyi, University of Washington

2:00 P.M. Cleveland Hotel

Session on Weldability and Research

Notch Toughness Characteristics of Submerged-Arc Weld Deposits
By I. L. Stern, N. A. Kahn and H. Nagler, New York Naval Shipyard

Effect of Metallurgical Variables on Transition Behavior in Charpy Slow-Bend and Impact Tests
By C. E. Harthauer, Watertown Arsenal Laboratories

Mild Steel Weld-Metal Porosity
By R. D. Stout, Lehigh University, and J. T. Ballass, Electric Boat Div. of General Dynamics Corp.

6:00 P.M. Cleveland Hotel

President's Reception





Tuesday Morning,

The Temperature Dependence of the Hardness of Pure Iron and Various Ferritic Steels

By *F. Garofalo* and *D. C. Marsden*, U.S. Steel Corp. and *G. V. Smith*, Cornell University

The Influence of Bainite on Mechanical Properties

By *R. F. Hehemann*, *V. Luhman* and *A. R. Troiano*, Case Institute of Technology

On the Cooling Transformations in Some

0.40% Carbon Constructional Alloy Steels

By *D. J. Blickwede* and *R. C. Hess*, Bethlehem Steel Co.

9:00 A.M. Carter Hotel

Symposium on Titanium

Panel Discussion on Sponge and Mill Production Economics

Speaker: *H. H. Kellogg*, Columbia University

Panelists: *W. E. Lusby, Jr.*, E. I. du Pont de Nemours and Co.

T. W. Lippert, Titanium Metals Corp. of America

P. Alspaugh, Electro Metallurgical Co.

V. W. Whitmer, Republic Steel Corp.

D. W. Kaufmann, Rem-Cru Titanium, Inc.

F. Vandenburg, Mallory-Sharon on Titanium Corp.

Panel Discussion on Fabrication Economics

Speaker: *S. A. Gordon*, Battelle Memorial Institute

Panelists: *G. Fairbairn*, North American Aviation, Inc.

W. H. Sharp, Pratt and Whitney Aircraft Div., United Aircraft Corp.

A. L. Rustay, Wyman-Gordon Co.

R. A. Paetz, Thompson Products, Inc.

W. R. Carpenter, Convair Div., General Dynamics Corp.

9:00 A.M. Hollenden Hotel

First Session on Developments in Nondestructive Testing Methods

Inspection of Small-Diameter Tubing by Eddy Current Methods

By *John W. Allen* and *Robert B. Oliver*, Oak Ridge National Laboratory

9:00 A.M. Carter Hotel

Research Seminar — Crystalline Imperfections and Mechanical Behavior

Delayed Yielding in a Substitutional Solid Solution Alloy

By *L. A. Shepard* and *J. E. Dorn*, University of California

Control of Strain Aging in Alpha Iron
By *E. R. Morgan*, Jones and Laughlin Steel Corp., and *J. C. Shyne*, Ford Motor Co.

Recovery of Cold Worked High-Purity Aluminum-Magnesium Alloys
By *E. C. W. Perryman*, Atomic Energy of Canada, Ltd.

Temperature Dependence of Annealing Phenomena in a Cold Rolled Aluminum Single Crystal
By *A. H. Lutts* and *P. A. Beck*, University of Illinois

Investigation of the Effect of Solutes on the Grain-Boundary Stress Relaxation Phenomenon
By *S. Weinig*, New York University, and *E. S. Machlin*, Columbia University

Some Observations on the Structure of Grain Boundary Fracture Surfaces
By *H. C. Chang* and *N. J. Grant*, Massachusetts Institute of Technology

9:00 A.M. Statler Hotel

Session on Steel

Temperability of Steels

By *L. D. Jaffe*, Jet Propulsion Laboratory, California Institute of Technology, and *Edward Gordon*, United Gas Corp.

Oct. 9, 1956

- Broad Beam Attenuation Data for Concrete for 70 to 250 Kvp. X-Rays
By E. Dale Trout, X-Ray Dept., General Electric Co.
- Design and Application of a Portable X-Ray Spectrograph
By Irwin I. Bessen, North American Philips Co., Inc.
- Standardization and Applications of Ultrasonic Surface Wave Inspection
By G. J. Binczewski, Kaiser Aluminum & Chemical Corp.
- Data Extraction in Nondestructive Testing
By H. N. Staats, Applied Research, Inc.

9:30 A.M. Cleveland Hotel

Session on Aircraft

- Design Requirements for Fusion Welding Titanium in Aircraft Applications
By R. Meredith, North American Aviation
- Fusion Welding of Magnesium-Thorium Alloys
By F. K. Lampson, Marquardt Aircraft
- Weld Planishing Improves Production of Aircraft Parts
By H. L. Mederith, Airline Welding and Engineering Co.

9:30 A.M. Cleveland Hotel

Session on Weldability and Research

- Brittle Fracture Initiation Tests
By C. Mylonas and D. C. Drucker, Brown University
- Brittle Fracture Propagation in Wide Steel Plates
By W. J. Hall, R. J. Mosborg and V. J. McDonald, University of Illinois
- The Effect of Microstructure on Notch Toughness—Part IV
By J. C. Danko, R. D. Stout and J. H. Gross, Lehigh University

9:30 A.M. Cleveland Hotel

Session on Design and Inspection

- How Welding Can Further Bridge Building Progress
By O. Blodgett, Lincoln Electric Co.
- Industrial Radiography by Gamma-Ray Projection From Radioactive Isotopes
By C. M. Dick, Metal & Thermit Corp.
- Greater Acceptance of Welding Through the Use of Inspection Methods
By J. R. Harrer, Magnaflux Corp.

9:30 A.M. Statler Hotel

Educational Lecture Course on Effect of Residual Elements on the Properties of Metals

- Residual Elements in Steel
By J. W. Halley, Inland Steel Co.

9:30 A.M. Statler Hotel

Joint session with on Furnace Atmospheres—Their Properties, Application, Control and Usage

- Review of Atmospheres—Their Types
By C. H. Vaughan, Electric Furnace Co.
- Review of Atmospheres—Their Applications
By Clarence E. Peck, Westinghouse Electric Corp.
- Types of Controllers Available
By W. Besselman, Leeds & Northrup Co.
- Methods of Controlling Atmosphere Converters
By Walter Holcroft, Holcroft & Co.
- Methods of Controlling Atmosphere in Furnaces
By Orville Cullen, Surface Combustion Corp.
- Atmosphere Furnaces—Their Safe Operation
By Norman H. Davies, North American Mfg. Co.

12:00 M. Statler Hotel

Awards Luncheon

Speaker: C. M. White, Chairman of the Board, Republic Steel Corp.





Tuesday Afternoon

2:00 P.M. Carter Hotel

Research Summaries — Atom Movements and Structure

Basal Plane Development in Electrodeposited Hexagonal Close-Packed Metals—Zinc, Titanium, Zirconium
By W. R. Opie, National Lead Co.

Surface Activity Methods for the Determination of Diffusion Coefficients in Solids
By R. H. Condit and C. E. Birchenall, Princeton University

X-Ray Diffraction Determination of the Coefficients of Expansion of Alpha-Uranium
By J. R. Bridge, C. M. Schwartz and D. A. Vaughan, Battelle Memorial Institute

Solubility of Boron in Fe-C and Variation of Saturation Magnetization, Curie Temperature, and Lattice Parameter of Fe_x(C, B) With Composition
By M. E. Nicholson, University of Minnesota

Crystal Structure of Delta-Prime Plutonium and the Thermal Expansion Characteristics of Delta, Delta-Prime and Epsilon Plutonium
By F. H. Ellinger, Los Alamos Scientific Laboratory

Structure of the Transition Phase, Omega, in Titanium-Chromium Alloy
By A. E. Austin and J. R. Doig, Battelle Memorial Institute

Neutron Diffraction Study of Textures in Drawn Body-Centered Cubic Metals
By R. A. Scaulin, University of Minnesota, and A. H. Geisler (deceased)

Relative Interfacial Energies of Symmetrical Tilt Grain Boundaries in Silver
By K. T. Aust, General Electric Co.

1:30 P.M. Hollenden Hotel

Session on Nondestructive Testing in the Petroleum and Chemical Industries

Quality Characteristics of Chemical Equipment and Their Control Through Non-destructive Testing
By C. J. Veith, E. I. du Pont de Nemours & Co., Inc.

Inspection of Piping
By H. Thielisch, Grinnell Co., Inc.

Ultrasonic Inspection in the Oil Refining and Related Industries
By D. J. Evans, Engineering Test Services, Inc.

A Fast, Economical Inspection for Drill Pipe
By F. M. Wood, Tuboscope Co.

2:00 P.M. Statler Hotel

Session on Steel

Impact Characteristics and Mechanical Properties of Leaded and Non-Leaded C-1050 and C-1141 Steels
By A. P. Weaver, Inland Steel Co.

Relation of Inclusions to the Fatigue Properties of S.A.E. 4340 Steel
By H. N. Cummings, F. B. Stulen and W. C. Schulte, Curtiss-Wright Corp.

Effect of Silicon on Transverse Properties and on Retained Austenite Content of High-Strength Steels
By John Vajda, J. J. Hauser and Cyril Wells, Carnegie Institute of Technology

Bend-Tensile Relationships for Toolsteels at High Strength Levels
By J. C. Hamaker, Jr., V. G. Strang and G. A. Roberts, Vanadium-Alloys Steel Co.

2:00 P.M. Cleveland Hotel

Session on Titanium

An Investigation of the Weldability of Ti-6% Al-4% V
By D. M. Daley, Jr. and C. E. Hartbower, Watertown Arsenal Laboratories

Problems Involved in Spot Welding Titanium to Other Metals
By F. W. McBee, Jr. and J. H. Henson, Defense Research Laboratory, and L. R. Benson, University of Texas.

Effects of Interstitial Elements on Welds in Alpha-Beta Titanium Alloys
By W. J. Lewis, M. L. Kohn, G. E. Faulkner and P. J. Rieppel, Battelle Memorial Institute

and Evening, Oct. 9, 1956

2:00 P.M. Carter Hotel

Symposium on Titanium

Panel Discussion on State of Analytical Development

Speaker: S. Vigo, Watertown Arsenal

Panelists: T. D. McKinley, E. I. du Pont de Nemours and Co., Inc.
J. E. Griffin, Mallory-Sharon Titanium Corp.
H. T. Clark, Jr., Rem-Cru Titanium Inc.
A. F. Ernster, Ford Motor Co.
W. A. Dupraw, National Research Corp.
M. J. Miles, Titanium Metals Corp. of America

Panel Discussion on Practical Problems Association With the Control of Interstitials

Speakers: L. S. Busch, Mallory-Sharon Titanium Corp.
H. Brown, Solar Aircraft Co.
C. Handova, North American Aviation, Inc.
Panelists: H. T. Clark, Jr., Rem-Cru Titanium, Inc.
T. Perry, Republic Steel Corp.
S. A. Herres, Titanium Metals Corp. of America
J. A. King, Thompson Products of Canada

2:00 P.M. Statler Hotel

Educational Lecture Course on Effect of Residual Elements on the Properties of Metals

Newer Metals — Titanium, Zirconium, Molybdenum and Chromium
By D. J. McPherson, Armour Research Foundation

2:00 P.M. Cleveland Hotel

Session on Inert-Arc Welding

Selection of Proper Inert-Gas-Shielded Arc Welding Process

By C. J. Sullivan and I. D. Holster, Jr., Air Reduction Sales Co.

Consumable-Electrode Inert-Gas Welding With Small-Diameter Wires

By K. E. Richter and J. F. M. Essig, Linde Air Products Co.

Inert-Gas-Shielded Metal-Arc Spot Process

By J. W. Kehoe and H. J. Bichsel, Westinghouse Electric Corp.

2:00 P.M. Cleveland Hotel

Symposium on Metallizing

Surfacing and Build-up

By R. J. McWaters, Metallizing Engineering Co., Inc.

Ceramic Coatings

By Representative of Norton Co.

Corrosion

By E. T. Englehart, Aluminum Research Laboratories

Combination Coatings

By C. J. Breitenstein, Metal-Cladding, Inc.

4:30 P.M. Cleveland Hotel

Educational Lecture Series

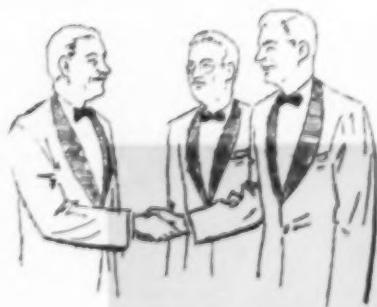
6:30 P.M. Hollenden Hotel

Hospitality Hour, Banquet and Awards



Evening Carter Hotel

Fellowship Dinner



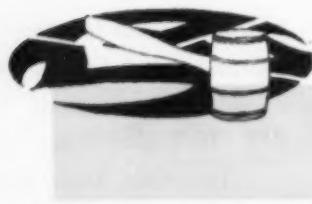
Wednesday Morning,

7:30 A.M. Statler Hotel

Chapter Chairmen's Breakfast

9:00 A.M. Statler Hotel

Annual Meeting



9:00 A.M. Hollenden Hotel

Session on Nondestructive Testing of Nuclear Reactor Components

Nondestructive Testing Problems in the Nuclear Reactor Field

By S. McLain and W. J. McGonnagle, Argonne National Laboratory, and E. C. Wood, General Electric Co.

Basic Principles and Techniques of Eddy Current Testing

By H. L. Libby, General Electric Co., Hanford Atomic Products Operation

Ultrasonic Methods and Techniques Used at the Savannah River Laboratory

By R. W. Leep and J. D. Ross, E. I. du Pont de Nemours & Co., Inc.

Inspection of Small-Diameter Tubing for Nuclear Reactor Applications

By R. B. Oliver, Oak Ridge National Laboratory

Ultrasonic Scanning and Recording Equipment

By W. N. Beck, Argonne National Laboratory

9:00 A.M. Carter Hotel

Research Summaries — Kinetics and Thermodynamics

Structure-Dependent Corrosion of Cu₃Au—Experiments Relating to the Mechanism of Stress Cracking of Homogeneous Solid Solutions

By Robert Bakish, Sprague Electric Co., and W. D. Robertson, Yale University

Growth of External Copper Layers During the Internal Oxidation of Dilute Cu-Al Alloys in a Cuprous Oxide-Copper Pack

By D. L. Wood, General Electric Co.

Free Energy of Formation of Mn₃C₆ From Vapor-Pressure Measurements

By C. L. McCabe and R. G. Hudson, Carnegie Institute of Technology

Oxygen in Liquid Iron-Nickel Alloys

By H. A. Wriedt, U. S. Steel Corp., and John Chipman, Massachusetts Institute of Technology

9:00 A.M. Carter Hotel

Research Summaries — Transformation

Study of the Iron-Silicon Order-Disorder Transformation

By F. W. Glaser, Alloy Precision Castings Co., and W. Ivanick, Schwarzkopf Development Corp.

Structural Changes During the Aging in an Aluminum-Magnesium-Zinc Alloy

By L. F. Mondolfo, Illinois Institute of Technology, N. A. Gjostein, Carnegie Institute of Technology, and D. W. Levinson, Armour Research Foundation

Sympathetic Nucleation of Ferrite

By H. I. Aaronson and C. Wells, Carnegie Institute of Technology

Electrical Resistivities and Phase Transformations of Lanthanum, Cerium, Praseodymium, and Neodymium

By F. H. Spedding, A. H. Daane and K. W. Herrmann, Iowa State College

Oct. 10, 1956

9:30 A.M. Cleveland Hotel

Session on Brazing and Surfacing

- Silver Brazing Lap Joints in Stainless Steel Tubing
By G. H. Bohn, Linde Air Products Co.
- Basic Characteristics of Some Heat Resistant Brazing Filler Materials
By W. Chang, General Electric Co.
- Longer Service Life Through Hard Facing for Petroleum Industry Equipment
By H. S. Gonser, Wall Colmonoy Corp.

9:30 A.M. Cleveland Hotel

Session on Filler Metal

- A New Nodular Cast Iron Welding Rod for Foundries and Fabricators
By R. O. Day, J. S. Snyder and H. V. Inskeep, Linde Air Products Co.
- Coating Ingredients Influence on Surface Tension, Arc Stability and Bead Shape
By T. H. Hazlett and Earl R. Parker, University of California
- Electrode Control in an Alloy Pressure Vessel Plant
By W. W. Weber, Colonial Iron Works Co.

9:30 A.M.

Plant Tour to
Euclid Div., General Motors Corp.

9:30 A.M. Cleveland Hotel

Session on Piping and Pipelines

- Status of Efforts to Develop Mechanized Pipeline Welding Methods
By P. S. Reed, Oil and Gas Journal
- Automatic Welding of Piping
By H. Thielsch and F. R. Jerome, Jr., Grinnell Co., Inc.
- Automatic Welding Applications at the Whiting Refinery
By R. C. Wheeler and R. M. Kolb, Standard Oil Co.

10:00 A.M. Statler Hotel

Campbell Memorial Lecture

- Metallurgy at Low Temperatures
By Charles S. Barrett, Institute for the Study of Metals, University of Chicago

12:00 M. Statler Hotel

Canadian Luncheon

12:00 M. Carter Hotel

Powder Metallurgy Luncheon

12:00 M. Statler Hotel

University Alumni Luncheons



Wednesday Afternoon and



1:30 P.M. Hollenden Hotel

Mehl Honor Lecture and National Meeting

Standards for Nondestructive Testing Practices
By *N. L. Mochel*, Westinghouse Electric Corp.



2:00 P.M. Statler Hotel

Session on Stainless

Precipitation Reactions in Austenitic Cr-Mn-C-N Stainless Steels
By *Chi-Mei Hsiao* and *E. J. Duliz*, Crucible Steel Co. of America

Martensitic Transformation in the Machining of Austenitic Stainless Steel
By *E. F. Erbin*, Titanium Metals Corp., *E. R. Marshall*, University of Vermont, and *W. A. Backofen*, Massachusetts Institute of Technology

Transformation Products in Cold Worked Austenitic Manganese Steel
By *R. K. Buhr* and *S. L. Gertman*, Department of Mines and Technical Surveys, Ottawa, and *James Reekie*, Northern Electric Co.

Metallography of Titanium-Stabilized 18-8 Stainless Steel
By *T. V. Simpkinson*, Republic Steel Corp.
Phase Relationships and Mechanical Properties of Some Iron-Chromium-Carbon-Nitrogen Alloys
By *G. F. Tisina* and *C. H. Samans*, Standard Oil Co.



2:00 P.M. Carter Hotel

Symposium on Magnetism

Fundamentals of Magnetism
By *J. B. Goodenough*, Massachusetts Institute of Technology

Kinetics of Magnetization
By *D. S. Rodbell*, General Electric Co.
Metallurgy of Magnetic Materials
By *J. J. Becker*, General Electric Co.



2:00 P.M. Carter Hotel

Research Summaries — Alloy Systems

Study of Ferrous Ternary Diagrams in Relation to Magnetic Interactions; the FeNiAl System
By *U. H. Roesler*, Westinghouse Research Laboratories

Melting Point Determination of Hafnium, Zirconium and Titanium
By *D. K. Deardorff* and *E. T. Hayes*, U.S. Bureau of Mines

Gamma Loop Studies in the Iron-Silicon and Iron-Silicon-Titanium Systems
By *G. G. Bentle* and *W. P. Fishel*, Vanderbilt University

Uranium-Bismuth System
By *R. J. Teitel*, Brookhaven National Laboratory

Uranium-Silicon Alloys
By *A. E. Kaufmann*, Nuclear Metals, Inc., *B. D. Cullity*, University of Notre Dame, and *G. Bitsianas*, University of Minnesota

Uranium-Zinc System
By *P. Chiotti*, *H. H. Klepfer* and *K. J. Gill*, Iowa State College

Constitution of Nickel-Rich Quaternary Alloys of the Nickel-Chromium-Titanium-Aluminum System
By *A. Taylor*, Westinghouse Research Laboratories

Solid Solubility of Carbon in Chromium
By *W. H. Smith*, General Electric Co.

2:00 P.M. Cleveland Hotel

Session on Resistance Welding

Recent Developments in Magnetic Force Welding
By *E. J. Funk*, Precision Welder & Flexopress Corp.

Regulated and Programmed Resistance Welding Control Systems
By *C. Sinclair*, General Electric Co.

Finish Mash Seam Welding
By *M. L. Begeman* and *W. J. Allen*, University of Texas

Evening, Oct. 10, 1956

2:00 P.M. Statler Hotel

Session on Nuclear Materials

Creep and Stress-Rupture Properties of Zirconium; Effect of Annealing Treatment
By R. W. Guard and J. H. Keeler, General Electric Co.

Transformation Kinetics of Uranium-Niobium and Ternary Uranium-Molybdenum-Base Alloys

By R. J. Van Thyne and D. J. McPherson, Armour Research Foundation

Transformation Kinetics of Uranium-Molybdenum Alloys

By R. J. Van Thyne and D. J. McPherson, Armour Research Foundation

The Plastic Deformation of Uranium on Thermal Cycling

By H. H. Chiswick, Argonne National Laboratory

2:00 P.M. Cleveland Hotel

Session on Pressure Vessels

Fabrication of Inert-Gas Welded Aluminum Tanks and Pressure Vessels
By R. J. Franz and Amel R. Meyer, Graver Tank and Mfg. Co., Inc.

The Properties of Pressure-Vessel Steels in Heavy Sections

By J. H. Gross and R. D. Stout, Lehigh University

Investigation of a Pressure Vessel Failure

By J. Heuschkel, Westinghouse Research Laboratories

2:00 P.M. Cleveland Hotel

Session on Stainless Steel

Properties of Austenitic Chromium-Manganese Stainless Steel Weld Metal
By W. T. DeLong and H. F. Reid, McKay Co.

The Plastic Ductility of Welded Joints in Austenitic Steel Piping at 1200°

By R. W. Emerson and R. W. Jackson, Pittsburgh Piping and Equipment Co.

Further Studies on Stainless Steel Hot Cracking

By H. Rischall and P. P. Puzak, Naval Research Laboratory

4:30 P.M. Cleveland Hotel

Educational Lecture Series

7:00 P.M.

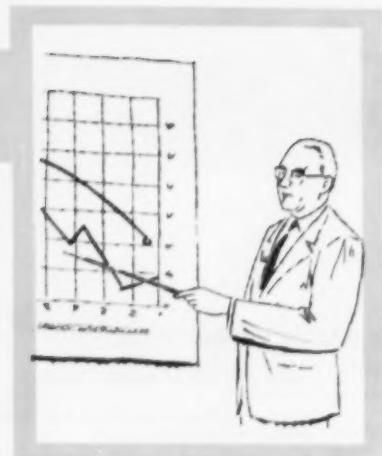
Field Trip to Ford Motor Co.

7:00 P.M. Cleveland Hotel

Annual Dinner

2:00 P.M.

Field Trip to National Carbon Co.



Thursday Morning,



9:30 A.M. Statler Hotel

Session on High Temperature

Effect of Sigma Phase on Co-Cr-Mo Base Alloys

By *Ronald Silverman*, Sylvania Electric Co., *William Arbitter*, Nuclear Development Corp. of America, and *Frank Hodis*, U. S. Army

An Austenitic Alloy for High-Temperature Use

By *R. W. Guard* and *T. A. Prater*, General Electric Research Laboratory

High-Temperature Rupture-Strength Properties of Chromium-Nickel Stainless Steels Containing Titanium and Boron

By *J. Solvaggi* and *L. A. Yerkovich*, Cornell Aeronautical Laboratories, Inc.

Effect of Environment on Creep-Rupture Properties of Some Commercial Alloys

By *Paul Shahinian*, Naval Research Laboratory

The Influence of Molybdenum on the Phase Relationships of a High-Temperature Alloy

By *H. J. Beattie, Jr.* and *F. L. VerSnyder*, General Electric Co.



9:00 A.M. Hollenden Hotel

Second Session on Developments in Nondestructive Testing Methods

The Ultrasonic Micrometer—a New Non-destructive Test Tool

By *H. A. Rocha*, Large Steam Turbine-Generator Dept., General Electric Co.

Production Inspection of Pipe and Tubing by the Immersed Ultrasound Method

By *Robert B. Oliver*, *R. W. McClung* and *J. K. White*, Oak Ridge National Laboratory



Field Performance of TVX System

By *J. E. Jacobs* and *A. L. Pace*, X-Ray Dept., General Electric Co.

Fluoroscopy With Electronic Image Intensification

By *A. L. Gobus*, Instruments Div., North American Philips Co., Inc.

9:30 A.M. Cleveland Hotel

Session on Piping and Tubing

Study of Interrupted Welding of Heavy-Wall Steam Pipe

By *I. A. Rohrig*, *J. O. Smith* and *E. G. Shifrin*, Detroit Edison Co.

Welding Heavy-Wall Carbon-Steel Pipe With CO₂ Shielding Gas

By *A. B. Dunning*, General Electric Co.

Effect of Zinc Phosphate Coatings on Flash Welding of Steel Tubing

By *J. F. Young* and *A. Phillips*, Douglas Aircraft Co., Inc.



9:30 A.M. Statler Hotel

Educational Lecture Course on Factors Affecting the Fatigue Endurance of Carburized Steel

Introduction

By *J. B. Bidwell*, General Motors Corp.

Physical Metallurgy of Carburized Steels

By *G. H. Robinson*, General Motors Corp.

Oct. 11, 1956

9:30 A.M. Carter Hotel

Conference on Thorium (Jointly with A.E.C.) Properties of the Metal

- The Role of Thorium Metal in the Nuclear Field
By *John P. Howe*, Atomics International
- Non-Nuclear Applications of Thorium Metal Other Than in Magnesium Technology
By *William C. Lilliendahl*, Westinghouse Electric Corp.
- The Uses of Thorium in Magnesium Technology
By *T. E. Leontis*, Dow Chemical Co.
- The Production of Thorium Compounds
By *Morton Smutz* and *John Barghusen*, Ames Laboratory, A.E.C.
- Reduction of Thorium Tetrafluoride by Calcium
By *Harley A. Wilhelm*, Ames Laboratory, A.E.C.
- Consumable-Electrode Arc Melting of Thorium
By *A. H. Roberson*, U.S. Bureau of Mines
- Powder Metallurgy of Thorium
By *B. Kopelman*, Sylvania Electric Co.
- Spectrographic Analysis of Thorium Metal
By *V. A. Fassel* and *Edward DeKalb*, Ames Laboratory, A.E.C.
- Chemical Analysis of Thorium Metal
By *C. J. Rodden* and *Morris W. Lerner*, New Brunswick Laboratory, A.E.C.
- Purification of Thorium Metal by the Iodide or Hot-Wire Process
By *Ivor E. Campbell*, Battelle Memorial Institute
- The Electrolytic Refining of Thorium
By *R. A. Noland*, Argonne National Laboratory

9:30 A.M. Statler Hotel

Discussion Forum on Die Wear and Die Life in Stamping Operations*

*Morning session by invitation.

9:30 A.M.

Plant Tour to Chevrolet-Cleveland Div. of General Motors Corp.

9:30 A.M. Cleveland Hotel

Session on Welding and Cutting

- Aspects of Crack Sensitivity in Machinable Deposits on Cast Iron
By *J. Broderick*, *R. D. Wasserman* and *J. F. Quaad*, Eutectic Welding Alloys Corp.
- Fundamental Concepts of Oxygen Cutting
By *R. L. Stoecker* and *W. B. Moen*, Air Reduction Co., Inc.
- Transverse Cracking Resulting From Oxygen Cutting
By *N. N. Breyer*, Continental Foundry & Machine Div., Blaw-Knox Co.

9:30 A.M. Cleveland Hotel

Session on Aluminum

- Chlorine Additions in Inert-Gas Metal-Arc Welding of Aluminum
By *A. R. Pfluger* and *M. B. Kasen*, Kaiser Aluminum and Chemical Corp., and *L. A. Cook*, Ravens Metal Products, Inc.
- The Thermal Stability of Cold Butt Welds in Aluminum and Copper
By *W. H. Bruckner* and *J. H. Sayles*, University of Illinois
- Fabricating Aluminum With Other Metals
By *K. V. Lutz*, All-State Welding Alloys Co., Inc.

10:00 A.M. Public Auditorium

Session on Automation in Literature Research

- A Report on the A.S.M. Mechanized Literature Searching Project
By *Allen Kent*, Center for Documentation and Communication Research, Western Reserve University



Thursday Afternoon

1:05 P.M. Public Auditorium

Open Discussion Forum on Die Wear and Die Life in Stamping Operations

1:30 P.M. Hollenden Hotel

Session on Nondestructive Testing of Aircraft

Relationship Between Defect Orientation
and Ultrasonic Indications
By R. E. Kleint, North American Aviation,
Inc.

Classification of Contractor's Standards for
the Procurement of Bureau of Aeronautics
Magnesium and Aluminum Castings
By E. L. Criscuolo and N. Modine, U.S.
Naval Ordnance Laboratory

Radiography in Production Control and
Inspection of Reliable Subminiature Tubes
By E. A. Kolm, Raytheon Mfg. Co.

X-Ray of Aircraft Components at the
Aircraft for Maintenance Purposes
By F. R. Richardson, U.S. Air Force

2:00 P.M. Statler Hotel

Educational Lecture Course on Factors Affecting the Fatigue Endurance of Carburized Steel

Residual Stresses in Carburized Steels
By W. S. Coleman, General Motors Corp.

Fatigue Durability of Carburized Steels
By R. L. Mattson, General Motors Corp.
Summary
By R. F. Thomson

2:00 P.M. Carter Hotel

Conference on Thorium (Jointly with A.E.C.) Properties of the Metal

Physical Constants, Crystal Structure and
Thermodynamic Properties
By J. F. Smith, Ames Laboratory, A.E.C.
Atomic Structure of Thorium, Its Electron
Energy and Other Considerations as to
Solid-State Physics

By T. G. Berlincourt, Atomics International
Preferred Orientation in Thorium
By L. K. Jetter and Carl J. McHargue, Oak
Ridge National Laboratory

Fabrication and Cladding of Thorium Metal
By John H. Frye and Jack Cunningham,
Oak Ridge National Laboratory

Recrystallization and Grain Growth in
Thorium Metal
By Edward J. Boyle, Electro Metallurgical
Co.

Mechanical Properties of Thorium Metal
and High-Thorium Alloys
By John Milke and Robert E. Adams, Oak
Ridge National Laboratory

Corrosion Resistance of Thorium Metal and
High-Thorium Alloys
By H. A. Pray and Associates, Battelle
Memorial Institute

Metallography of Thorium
By Harriet P. Roth, Nuclear Metals, Inc.
Irradiation Damage in Thorium Metal
By Frank G. Foote, Argonne National
Laboratory

Thorium Alloy Systems
By H. A. Saller and Frank A. Rough,
Battelle Memorial Institute
Hazards Associated With Thorium Metal-
lurgy
By Adolph Voight and Milo Voss, Ames
Laboratory, A.E.C.

and Evening, Oct. 11, 1956

2:00 P.M. Statler Hotel

Session on High Temperature

The Mechanical Properties of Iron-Aluminum Alloys

By W. Justusson, V. F. Zackay and E. R. Morgan, Ford Motor Co.

Some High-Temperature Oxidation Characteristics of Nickel With Chromium Additions

By G. E. Zima, International Nickel Co., Inc.

The Mechanical Properties of Swaged Iodide-Base Chromium and Chromium Alloys

By D. J. Maykuth and R. I. Jaffee, Battelle Memorial Institute

Effect of Dispersion of Alpha Phase on the High-Temperature Fatigue Properties of Alpha-Beta Brass

By J. E. Breen, Naval Research Laboratory, and J. R. Lane, National Research Council

Aging Reactions in Certain Superalloys

By W. C. Hagle and H. J. Beattie, Jr., General Electric Co.

2:00 P.M. Public Auditorium

Publications on Industrial Uses of Atomic Energy

The Literature of Industrial Power Uses of Atomic Energy

By Fred E. Croxton and Philip Leslie, Goodyear Atomic Corp.

The Literature of Radiation Effects on Materials

By James B. Dodd, Babcock & Wilcox Co.

The Literature of Radioactive Testing Techniques

(Speaker to Be Announced)

2:15 P.M. Public Auditorium

Open Discussion Forum on Die Wear and Die Life in Stamping Operations

6:30 P.M. Manger Hotel

Dinner and Social Hour

7:30 P.M. Statler Hotel

Annual Banquet

Speaker: John R. Dunning, Dean of Engineering, Columbia University



Friday Oct. 12, 1956

9:00 A.M.

Field Trip to Penton Publishing Co.

9:30 A.M. Cleveland Hotel

Session on Molybdenum and Zirconium

Ductility of Tungsten-Arc Welds in Molybdenum

By R. E. Monroe, N. E. Weare and D. C. Martin, Battelle Memorial Institute

The Influence of Nitrogen on the Ductility of Molybdenum Welds

By W. N. Platte, Westinghouse Electric Corp.

Notch Slow-Bend Testing of Zirconium and Zircaloy-2

By R. G. Wheeler, General Electric Co.

9:30 A.M. Cleveland Hotel

Session on Shop Management

Organization of Shop Management for Quality Welding

By W. B. Bunn, M. W. Kellogg Co.

Maintaining Workmanship Standards for Quality Welding

By Howard B. Cary, Marion Power Shovel Co.

9:30 A.M. Cleveland Hotel

Session on Processes

The Motor Arc Welding Process

By C. C. Stone and R. A. Noland, Argonne National Laboratory

High-Frequency Continuous Seam Welding of Ferrous and Non-Ferrous Tubing

By H. B. Osborn, Jr., Tocco Div., Ohio Crankshaft Co.

Developed Procedures for the Flexible Electrode Submerged-Arc Welding Process

By M. H. Fritsche, Westinghouse Electric Corp.

12:00 M. Public Auditorium

Distinguished Service Luncheon for 25-Year Members and Students

2:00 P.M.

Tour of Thompson Products Co.



EXHIBITOR LISTING

A		
Aaron Machinery Co., Inc.	Booth 2224	American Cyanamid Co. 1501 Heat treating compounds and metallurgical additives.
Acetogen Gas Co.	2656	American Cystoscope Makers, Inc. 2836 Borescopes and optical flats.
Gas mixing unit for cutting and brazing applications.		American Gas and Electric Co. 2007 Products of companies served by the American Gas and Electric Co.
Acme Steel Co.	1933	American Gas Assoc. 2859 Industrial gas furnaces, ovens and burners.
Metal stichers and steel strapping.		American Gas Furnace Co. 2841 Automatic heat treating equipment.
Acme Tool Co.	715	American Herforder Corp. 2033
Universal lathe tool holder and inspection tools.		American Machinist 2406
Adamas Carbide Corp.	1747	American Metal Market 1745 <i>American Metal Market and Metal Statistics.</i>
Sintered aluminum oxide cutting tool material and tungsten carbide.		American Optical Co. 1136 Metallographic equipment.
Advancee Glove Mfg. Co.	2803	American Positive Grip Vise Corp. 2773 Ampogrip holding fixtures.
Complete line of safety gloves.		American Pullmax Co. Inc. 2521 Universal shearing and forming machines.
Aeronautical Service-Engineering	2751	American Silver Co., Inc. 930 Very thin, close tolerance metal strip.
Aircraft and helicopter parts shot-peened.		American Society for Metals 1706 Information on World Metallurgical Congress and Metals Engineering Inst.
Aeroprojects Inc.	2333	Amperex Electronic Corp. 2635 Electronic tubes for industrial applications.
Ultrasonic welding and brazing equipment.		Apex Tool & Cutter Co., Inc. 2816 Inserted tooth type milling cutters.
Ajax Electric Co.	1609	Applied Research Laboratories 2112 Spectrographic equipment.
Salt bath furnace equipment.		Arcweld Manufacturing Co. 2302 High-temperature testing equipment.
Ajax Electrothermic Corp.	1609	
High-frequency induction furnaces.		
Ajax Engineering Corp.	1609	
Low-frequency induction melting furnaces.		
Aldridge Industrial Oils Inc.	525	
Heat treating and metalworking compounds.		
Al-Fin Div., Fairchild Engine & Airplane Corp.	2324	
Molecularly bonded bimetallic castings.		
Allegheny Ludlum Steel Corp.	451	
Heat and corrosion resistant alloys, tool and die steels and cemented carbides.		
Allis-Chalmers Mfg. Co., Buda Div.	2509	
Openhearth diesel fork lift truck.		
Allison Div.	1816	
Abrasive cutting wheels.		
Alloy Engineering & Casting Co.	936	
Heat and corrosion resistant castings.		
American Brake Shoe Co.	215	
Heat resistant and precision engineered castings.		
American Cast Iron Pipe Co.	2144	
Centrifugal castings.		
American Chain & Cable Co.	1816	
See Allison Div., Campbell Machine Div. and Wilson Mechanical Instrument Div.		
American Chemical Paint Co.	2332	
Metalworking and finishing compounds.		
B		
Aro Spot Welder Div.	2733	
Portable spot welders.		
Ashworth Bros., Inc.	2660	
Wire belts for heat treating and material handling.		
Assembly Products, Inc.	1702	
Temperature controls and meter-relays.		
Atlas Mineral Products Co.	2729	
Corrosion resistant cements and plastics.		
Audubon Wire Cloth Corp.	2728	
Corrosion and heat resistant conveyor belts.		
Babcock & Wilcox Co.		
Tubular Products Div.	522	
Tubular products and extrusions.		
Baird Associates-Atomic Instrument Co.	1234	
Direct reading spectrometer and spectrographic accessories.		
Balerank Inc.	521	
Paint pumping equipment.		
Baldwin-Lima-Hamilton Corp.	2104	
SR-4 devices and equipment, testing equipment.		
Balteau Electric Corp.	2622	
Portable industrial X-ray units.		
Banner Welder, Inc.	2769	
Resistance welding equipment.		
Barber-Colman Co., Wheleco Instruments Div.	1829	
Recorders and controllers with combustion safeguards.		
Barer Engineering & Machinery Co. Ltd.	2316	
Lathes, drill presses, shapers and grinders.		
Barker Engineering Co.	2830	
Milling machines.		
Bausch & Lomb Optical Co.	422	
Metallographic equipment.		



Bean & Co., Morris	920
Antioch process aluminum castings.	
Bede Products Corp.	1101
Airless spray coating equipment.	
Bendix Aviation Corp.	2123
Ultrasonic cleaning equipment and nonferrous castings.	
Beryllium Corp.	1834
Beryllium copper alloys and pure beryllium.	
Binks Mfg. Co.	2755
Paint spraying equipment.	
Black Drill Co., Inc.	914
Drills for drilling hardened steel.	
Blakeslee & Co., G. S.	1019
Cleaning equipment.	
Boggis, Henry P. & Co.	2874
Tap grinders and tap-sharpening equipment.	
Branson Ultrasonic Corp.	2145
Ultrasonic generators and thickness gages.	
Brennen, Bucci & Weber Inc.	1732
Spot welder and portable arc welder.	
Brinkmann & Co. Inc., C. A.	201
Metallographic and other laboratory equipment.	
Brush Beryllium Co.	531
Beryllium and beryllium alloys.	
Brush Electronics Co.	1726
Equipment for surface finish measurement and metal identification.	
Buck Mfg. Co.	2546
Magnetic Drill Presses and clamping equipment.	
Buck Tool Co.	1528
Compensating power chucks.	
Budd Co.	1707
Gamma radiation sources for industrial radiography.	
Buehler Ltd.	260
Equipment for preparation of metallographic specimens.	

C

Cadmet Corporation	2667
Investment castings and Ampco wear strips.	
Cam-Lok Div., Empire Products, Inc.	2520
Waterproof connectors and molding kits.	
Cammann Mfg. Co.	1737
Metal disintegrators for machining hard metal.	
Campbell Machine Div.	1816
Wet and dry abrasive cutting machines.	
Carbide & Carbon Chemicals Co.	1608
Fire resistant hydraulic fluids, synthetic lubricants and metalworking fluids.	
Carlingo Commodities Corp.	2107
Flame hardening equipment.	
Carter Controls, Inc.	803
Air and hydraulic cylinders, valves and rotary actuators.	
Center for Documentation and Communication Research	270
Literature searching machine.	



Central Foundry Div., General Motors Corp.	2134
Iron and steel shell-molded castings.	
Chicago Rivet & Machine Co.	2529
Tubular rivets and automatic rivet setting machines.	
Chilton Co.	1402
<i>Iron Age, Automotive Industries.</i>	
Cincinnati Sub-Zero Products Co.	2573
Production chilling machines.	
Circo Equipment Co.	2101
Spray washer, vapor degreaser and ultrasonic metal cleaning equipment.	
Cities Service Oil Co.	1229
Hydraulic oil, cutting oils, greases and heat prover.	
Clementina Ltd.	2673
Blast cleaning equipment.	
Cleveland Designers & Consultants, Inc.	2873
Cleveland Electric Illuminating Co.	911
Information on Cleveland and northeast Ohio.	
Cleveland Grinding Machine Co.	337
Grinding equipment and accessories.	
Cleveland Metal Abrasive Co.	1908
Cleaning and peening shot and grit.	
Climax Molybdenum Co.	360
Molybdenum as an alloying element.	
Cobalt Information Center	542
Metallurgical applications of cobalt.	
Cold Metal Products Co.	1120
Precision cold rolled strip steel.	
Collins Microflat Co.	939
Black granite surface plates.	
Commander Mfg. Co.	736
Multiple drill and tapping heads.	
Consolidated Vacuum Div., Consolidated Electrodynamics Corp.	1929
High-vacuum equipment.	
Continental Drill Corp.	532
Continental Industrial Engineers, Inc.	2831
Heat treating equipment.	
Cooper Metallurgical Associates	1033
Pure boron, boron alloys and borides.	
Copperweld Steel Co. Steel Div.	311
Leaded alloy and carbon steels.	
Ohio Seamless Tube Div.	
Seamless and welded tubing.	
Crampton Mfg. Co.	1730
Crane Packing Co.	2617
Lapping machine and mechanical packings.	
Curtiss-Wright Corp.	2032
Ultrasonic equipment; forgings, extrusions and castings.	

D

Dake Corp.	2554
Arbor, hydraulic shop and guided platen presses.	
Delta Power Tool Div., Rockwell Mfg. Co.	1916
Drill presses, grinders and lathe units.	
DeSanto & Son, Inc., A. P.	1942
Abrasive cutoff machines and grinding wheels.	
Detrex Chemical Industries, Inc.	1907
Cleaning and finishing compounds and equipment.	
Detroit Testing Machine Co.	1806
Hardness, tensile and ductility testers.	
De Walt, Inc.	2670
Radial arm metal cutting machinery; dynamic power brakes.	
Diley Mfg. Co.	810
Magnetic grip-shields.	
Douston Div., Henry, H. K. Porter Co. Inc.	2731
Complete line of metalworking saws.	
Diversey Corp.	1012
Cleaning and phosphatizing chemicals.	
Dixon Sintaloy Inc.	2774
Powder metal parts.	
Dochler-Jarvis Div., National Lead Co.	2111
Die castings.	
Driver Co., Wilbur B.	248
Wrought special-purpose alloys.	
Driver-Harris Co.	2411
Wrought and cast heat resistant alloys; thermocouples.	
Drop Forging Assoc.	2530
Drop forgings.	

DuBois Co., Inc. 2423
Cleaning and processing compounds.

Du Pont de Nemours & Co.

Inc.
Electrochemical Dept. 1032
Degreasing process.

Explosives Dept. 1030
Industrial expansion rivets.

Dynamic Gear Co. 2871
Precision gears and gear assemblies.

Easco Products Div.
Electro Arc Sales Co. 1204
Metal disintegrators and conversion units.

Eastman Kodak Co. 1002
New type AA industrial X-ray film.

East Shore Machine Products Co. 2560

Eclipse Fuel Engineering Co. 1724
Radiant heating gas burners and other equipment.

Electric Furnace Co. 1041
Industrial heat processing furnaces.

Electro Metallurgical Co. 1608
Titanium; Cr-Ni-Mn stainless steels.

Elox Corp. of Michigan 2131
Electron drills and precision electrical discharge machinery.

Enamelstrip Corp. 2628
Precoated steel in coils.

Engelberg Huller Co., Inc. 2746
New centerless grinder and wide sheet grinder.

Erona Corp. 937
Zeiss Metallographic equipment.

Eriez Mfg. Co. 2716
Magnetic separators and automation units.

Exomet, Inc. 2571
Exothermic products and custom alloys.

F

Fabristeel Products, Inc. 1421
Clinch nuts and diversified fasteners.

Fawick Airflex Div.,
Fawick Corp. 1934
Punch press, clutches, brakes and controls.

Fenn Mfg. Co. 331
Combination two-high, four-high rolling mill.

Fenway Machine Co. Inc. 1204
Portable metal cutting tools.

Ferrotherm Co. 536

Forest City Foundries Co. 2856
Gray iron castings.

Fulton Foundry & Machine Co. 2753

G
Gas Appliance Service, Inc. 2837
Gas-fired heating equipment.

Gas Machinery Co. 2833
Industrial furnaces.

Gasway Corp. 2864
Roller coated materials.

General Alloys Co. 351
Heat resisting and stainless steel castings and fabrications.

General Electric Co.,
Apparatus Sales Div. 305
Metallurgical Products Dept. 2124

Carboly cemented carbide and cemented oxide tool materials.

X-ray Dept. 1104
Industrial X-ray equipment.

General Riveters, Inc. 2616
Portable screwdriver and riveter.

General Ultrasonics Co. 2866
Ultrasonic generators.

Goodrich Co., B. F. 2535
Rivnuts.

Graham Machine Tool Co. 2403
Milling machines and surface grinders.

Graham Transmissions, Inc. 804
Variable speed transmissions for automated equipment.

Gray Co., Inc. 2618
Paint spray equipment.

Gries Industries, Inc. 550
Die castings and hardness testers.

Gulf Oil Corp. 1527
Oils and lubricants for the metal industry.

H

H & H Research Co. 715
Portable electric tools.

HPL Mfg. Co. 1240
Stampings.

Hacker & Co., Wm. J. 1709
Metallographic equipment.

Hamler Industries, Inc. 907
Ammonia distribution, steel fabrication and industrial X-ray Service.

Hammond Machinery Builders, Inc. 1250
New electrolytic chip-breaker grinder and electrolytic oscillating carbide tool grinder.

Harman Assoc., F. Ward 2718
Scale models and templates for plant layouts.

Harper Electric Furnace Corp. 724
Electric sintering and brazing furnaces.

Harris Colorific Co. 223

Harshaw Scientific Div.,
Harshaw Chemical Co. 2647
Metallurgical laboratory equipment.

Haynes Stellite Co. 1608
Heat and corrosion resistant alloys, investment castings, hard facing materials and cutting tools.

Heatbath Corp. 1506
Heat treating salt baths; finishing compounds.

Heil Process Equipment Corp. 2766

Heli-Coil Corp. 2415
Screw thread inserts.

Hevi Duty Electric Co. 209
Heat treating equipment.

High Vacuum Equipment Corp. 2702
Laboratory vacuum melting furnace.

High Voltage Engineering Corp. 720
X-ray generators and particle accelerators.

Hobart Brothers Co. 2541
Electric arc welders; welding supplies and equipment.

Holcroft & Co. 346
Industrial furnaces and gas generators.





Holden Co., A. F.	1415
Automatic carousel process conveyor.	
Holger Andreasen, Inc.	537
Portable X-ray units for industrial radiography.	
Holliday Co., R. L.	704
Hones Inc., Charles A.	2857
Industrial gas burners.	
Houghton & Co., E. F.	1145
Compounds for drawing, cutting and surface treatment of metals.	
Howard Foundry Co.	212
Aircraft and commercial quality castings.	
Huck Mfg. Co.	2805
Bolts, blind rivets and driving tools.	

Illinois Testing Laboratories, Inc.	1214
Temperature measuring and controlling instruments.	
Industrial Heating	2765
Industrial Heating Equipment Co.	2561
Complete line of heat treating furnaces.	
Industrial Press Machinery	1729
and engineering books.	
Industrial Publishing Group	801
Industrial Tectonics, Inc.	2517
Special alloy bearings and balls.	
Instron Engineering Corp.	2430
Testing equipment.	
International Nickel Co., Inc.	402, 408
Nickel and nickel alloys; movie on "Mining for Nickel."	
Invincible Vacuum Cleaner Mfg. Co.	2703
Industrial vacuum cleaners.	
Ipsen Industries, Inc.	321
Endothermic generator with automatic ratio control; heat treating furnaces.	
Ivy Co.	2003
Fatigue testing equipment.	

Janney Cylinder Co.	2621
Centrifugal castings and machined products.	
Jarrell-Ash Co.	1111
Spectrometers and spectrographic equipment.	
Jergens Tool Specialty Co.	2572
Jig and fixture components.	
Jerphak-Bayless Co.	814
Thread grinding equipment.	
Jiffy Disintegrators, Inc.	2761
Jiffy disintegrator machines for removing broken taps.	
Johnson & Son, Inc., S. C.	1924
New water-soluble cutting fluid.	
Jomac Inc.	2715
Industrial work gloves.	

Kemp Mfg. Co., C. M.	2853
Industrial gas combustion equipment.	
Kennametal Inc.	1824
Tungsten and titanium carbide products.	
Kerns Co., L. R.	2547
Drawing, cutting, grinding and forging compounds.	
King Tester Corp.	253
Brinell testing machines and microscopes.	
Kinney Mfg. Div., New York Air Brake Co.	728
Vacuum equipment.	
Kirkhof Mfg. Co.	2860
Knight Models, Inc.	2756
Three-dimensional model of metalworking plant.	
Kolcast Industries, Inc.	1119
Investment castings.	
Kolene Corp.	1330
Salt bath cleaning processes.	
Krouse Testing Machine, Inc.	2512
Kux Machine Co.	1420
Diecasting machine and powdered metal press.	

L
Laboratory Equipment Corp. 2655
 New induction furnaces; carbon and sulphur analyzers.

Lake Shore, Inc. 2542
 Surface plates, base plates, engine jacks and stands.

Lakeside Steel Improvement Co. 306
 Heat treating and testing service.

Lee Co., K. O. 2044
 Grinding machines and accessories.

Leeds & Northrup Co. 1129
 Steam Homo furnace; gas analysis and temperature control demonstrations.

Leitz, Inc., E. 702
 Dilatometer-heating microscope and bench microscopes.

Lempeo Industrial, Inc. 1236
 Grinders and die sets.

Lepel High Frequency Laboratories, Inc. 2211
 Induction heating equipment.

Lewis Machine Co. 2002
 Wire straightening and cutting machine.

Lincoln Electric Co. 440
 Welding equipment and supplies.

Lindberg Engineering Co. 431
 Heat treating equipment.

Linde Air Products Co. 1608
 Heliarc cutting and spot welding, flameplating, oxy-acetylene welding and cutting.

Loftus Engineering Corp. 2650
 Industrial furnaces.

Logansport Machine Co., Inc. 2207
 Special air and hydraulic equipment.

Los Angeles Dept. of Water & Power 2329
 Industrial opportunities in the San Fernando Valley.

Lufkin Rule Co. 1721
 Precision tools, measuring tapes and rules.

Lynchburg Foundry Co. 1519
 Ductile and gray iron castings.

M
Machlett Laboratories, Inc. 2438
 Electronic tubes for X-ray and induction heating equipment.

Magnaflex Corp. 231
 New Magnaflex and Zyglo inspection materials.

Magnethermic Corp. 2336
 Aluminum extrusion press with Magnethermic induction billet heater.

Magnetic Analysis Corp. 1235
 Magnetic analysis equipment.

Malayan Tin Bureau 2410
 Applications of tin in industry.

Manganese Steel Co. 2728
 Forged manganese steel screens and plates.

Manufacturers Processing Co. 2821
 Degreasing equipment.

Marquette Metal Products	
Div.	2032
Precision spring clutches.	
Martindale Electric Co.	1212
Metal-cutting circular saws, rotary files and electrical equipment.	
M. B. I. Export and Import Ltd.	2312
Horizontal optical jig borer and special small tools.	
McGuire, Thos. B.	907
Metal Carbides Corp.	2024
Tungsten carbide cutting tools and wear resistant parts.	
Metal Progress	240
Metal Removal Co.	2033
All-purpose abrasive.	
Metallizing Co. of America	506
Metallizing equipment.	
Metallizing Engineering Co., Inc.	2233
Thermospray equipment for hard surfacing.	
Metallurgical, Inc.	818
Heat treating service.	
Metalwash Machinery Corp.	2847
Metal cleaning equipment.	
Met-L-Chek Co.	704
Met-L-Chek flaw-finder and dye penetrant.	
Micrometrical Mfg. Co.	432
Profilometer and other surface control equipment.	
Miller Fluid Power Div.	1623
Air and hydraulic cylinders.	
Minneapolis-Honeywell Regulator Co., Industrial Div.	312
Saturable reactor and process control systems.	
Modernair Corp.	2609
Fluid power devices.	
Mohawk Tools, Inc.	716
Subland tools, also size-optional drills.	



Naresco Equipment Corp.	2108
New 12-lb. vacuum induction furnace and other vacuum equipment.	
National Carbon Co.	1608
Carbon and graphite products.	
National Cored Forgings Co., Inc.	445
Cored and solid nonferrous forgings.	
National Malleable and Steel Castings Co.	1703
Malleable iron and steel castings.	
National Precision Casting Corp.	2828
Ferrous and nonferrous investment castings.	
National Spectrographic Laboratories, Inc.	2830
New hydrogen and carbon analyzer.	
National-Standard Co.	2608
Specialty steel wires and wire cloth.	
Nelson Stud Welding Div., Gregory Industries, Inc.	1930
Stud welding equipment.	

New Hermes Engraving Machine Corp.	2510
Pantograph engraving machines.	
Nicholas Equipment Co.	2424
Polishing and grinding machines.	
Nichols Co., R. W.	1323
Air control valves, index tables and presses and automatic drill heads.	
North American Mfg. Co.	1512
Gas burners and turbo blowers.	
North American Philips Co., Inc.	2635
X-ray spectrographic equipment.	
North American Viking Drill Co.	532
High speed and carbon steel tap and twist drill sets.	
Norton Co.	2414, 2657
O	
Oakite Products, Inc.	941
Materials and equipment for cleaning, finishing, machining and grinding.	
Ohio Hydro Deburring Co.	2564
Barrel finishing equipment.	
Ohio Metal Working Products Co.	505
Ohio Nut & Bolt Co.	2760
Ohio weld fasteners.	
Ohio Steel Foundry Co.	910
Heat and corrosion resistant alloy castings.	
Olsen Testing Machine Co., Tinus	1137
Testing machines.	
O'Neil-Irwin Mfg. Co.	1410
Hand and power operated benders, brakes and shears.	
Osborn Mfg. Co.	2116
Brushamatic machines and industrial brushes.	
Overbeke-Kain Co.	2620
Portable workbench and tool carrier.	

Precision Steel Warehouse, Inc.	2140	Scott Paper Co.	703	Struers Chemical Laboratory	815
Precision brand steel and copper alloys.		Towels and industrial wipers.		Sunbeam Corp., Industrial Furnace Div.	
Precision Tube Co., Inc.	2832	Seovill Mfg. Co., Inc.	1812	Gas carburizing furnace and atmosphere quench equipment.	942
Seamless nonferrous tubing.		Sealol Corp.	1505	Superior Foundry, Inc.	1207
Pressco Casting & Mfg. Corp.	2615	Fluid transfers and adapters for high-pressure coolant applica-		Superior Pneumatic & Mfg., Inc.	2819
Cast nonferrous gears.		tion.		Air hammers and pneumatic ac-	
Production Machine Co.	1809	Sentry Co.	1203	cessories.	
Centerless grinding machine and surfacing machines.		High speed steel hardening furnace.		Superior Tube Co.	1220
Pyrofax Gas Corp.	1608	Service Diamond Tool Co.	1735	Small diameter metal tubing.	
Pyrofax LP gas for industrial purposes.		Hardness testing machines and accessories.		Supreme Products, Inc.	2721
Pyrometer Instrument Co., Inc.	1037	Sheldon Machine Co., Inc.	1723	Surface Combustion Corp.	421
Surface, radiation, immersion and indicating pyrometers.		Variable speed drive lathe with automatic speed selector.		Heat treating furnaces and steel mill equipment.	
R		Shell Oil Co.	1316	Swift Industrial Chemical Co.	836
Radiator Specialty Co.	2867	Cutting and quenching oils.		Heat treating and finishing chemicals.	
Rubber and plastic products.		Sieburg Industries, Inc.	2770		
Rameo Equipment Corp.	2564	Equipment for machining ten-			
Vapor degreasers and power spray washers.		sile specimens.			
Ransburg Electro-Coating Corp.	1714	Sinclair Refining Co.	2646	Taylor Instrument Co.	2817
Electrostatic paint spraying equipment.		Quenching, grinding and soluble oils.		Temperature and pressure indicators and controllers.	
Ranshoff, Inc.	2734	Sinton Corp. of Americas	1823	Technic, Inc.	811
Automatic ultrasonic cleaning machine.		Cutting tools and holders.		Plating equipment and supplies.	
Raytheon Mfg. Co.	2848	Skil Corp.	2239	Tech-Pacific Corp.	1730
Electronic welding and impact grinding equipment.		Portable power tools.		Metalworking equipment.	
Reeves Div., Reid-Avery Co.	1130, 2861	Skinner Chuck Co.	2601	Telenews Productions Inc.	801
Welding supplies.		Hand chucks, machine vises and power chucking equipment.		Industrial Publishing Group, <i>Industry & Welding</i> .	
Reliance Electric & Engineering Co.	1130	Socony Mobil Oil Co., Inc.	1840	Tempi Corp.	929
Renton & Co., R. W.	2852	Cutting oils and rust preventa-		Temperature indicating mate-	
Cleaning and finishing equip- ment.		tives.		rials.	
Richards Co., J. A.	1230	Southone Div., South Chester Corp.	1017	Texas Co.	1602
Multiform benders.		Drive rivets and fasteners.		Cutting and drawing com-	
Ricbie Testing Machines Div., American Machine & Metals, Inc.	241	Special Libraries Assoc.	370	pounds.	
Testing machines.		Technical and reference books.		Thomas Publishing Co.	2869
Rodgers Hydraulic, Inc.	2722	Spee-Flo Co.	2772	<i>Thomas' Register of American Manufacturers Industrial Equip- ment News</i> .	
Platen press.		Painting equipment.		Thomson Electric Welder Co.	1751
Rotherm Engineering Co.	711	Spencer Scientific Instruments	1136	Flash welder equipped with synchro-shear.	
Expansion joints, revolving joints and piping compensators.		Spencer Turbine Co.	2749	Thor Power Tool Co.	2723
Ryerson & Son, Inc., Joseph T.	405	Portable vacuum cleaners, turbo- compressors and pneumatic con- veying systems.		Portable air and electric tools.	
New E-Z-Cut (leaded) steel plate and flamecut irregular shapes.		Sperry Products, Inc.	1428	Tickle Engineering Works, Inc., Arthur	2326
S		Ultrasonic inspection equipment.		Alumicoat and Alumbond process.	
S.P. Mfg. Corp.	2850	Spitfire Tool Co.	2550	Timken Roller Bearing Co., Steel & Tube Div.	1051
Air and hydraulic cylinders.		Lapping machines.		Alloy steel, graphitic tool steels and Hollowbar tool steel.	
Scherr Optical Tools, Inc., Geo.	710	Standard Electric Tool Co.	1047	Tinnerman Products, Inc.	1029
Microscopes and inspection equipment.		Precision spindles and variable speed grinders.		Standard and special engineered fasteners.	
Schrader's Son Div., A.	1812	Standard Oil Co. (Ohio)	2307	Titanium Alloy Mfg. Div., National Lead Co.	2111
Pneumatic valves and cylinders.		Petroleum products.		Zirconium and titanium alloys and compounds.	
Sciaky Bros. Inc.	2206	Standard Parts Co.	2671	Titanium Metals Corp. of America	1241
Resistance welding equipment and controls.		Stanley Electric Tools Div.	1741	New titanium alloys.	
Scientific Electric	2502	Drills, sanders and grinders.		Toeco Div., Ohio Crankshaft Co.	2212
Paint spraying equipment.		Starrett Co., L. S.	919	Automated induction heating equipment.	
		Precision instruments and hand tools.		Torit Mfg. Co.	935
		Steel City Testing Machines, Inc.	1324	Torit dust collectors.	
		Machines to test physical prop- erties of metals.		Torsion Balance Co.	1740
		Stimpson Co., Inc., Edwin B.	411	Combination hardness tester, microhardness tester, analytical and industrial balances.	
		Rivets, stampings and screw machine parts.			
		Stokes Machine Co., F. J.	1520		
		Powder metal press; vacuum equipment.			

Trerice Co., H. O.	816
Thermometers, temperature and pressure regulators.	
Tubular Micrometer Co.	1009
Precision measuring instruments.	
Turco Products, Inc.	2234
Aluminum conversion coating, phosphate coatings and chemical milling supplies.	
Uddeholm Co. of America, Inc.	815
Toolsteel and laboratory equipment.	
Union Carbide & Carbon Corp.	1608
See Linde Air Products Co., Carbide and Carbon Chemicals Co., Electro Metallurgical Co., Pyrofax Gas Corp., National Carbon Co. and Haynes Stellite Co.	
Union Mfg. Co.	2629
Lathe chucks, die sets and accessories.	
United Scientific Co.	2661
Microscopes and metallographic equipment.	
United Shoe Machinery Corp.	1835
Blind rivets, eyelets and eyelet machinery.	
United Wire & Supply Corp.	554
Brazing alloys and fluxes; wire and seamless drawn tubing.	
Universal Castings Corp.	2754
Nonferrous castings.	
Universal Tumbling Supply Co.	2570
Precision tumbling materials.	
Uniworld Research Corp. of America	809
Age hardenable, corrosion and heat resistant stainless steels; corrosion resistant cast irons; low-temperature braze welding.	
Upton Electric Furnace Co.	1509
Graphite electrode salt bath furnace.	
U.S. Automatic Corp.	1101
U.S. Electrical Motors, Inc.	2230
Variable speed motors.	
U.S. Gypsum Co.	830
Cements, plasters for precision castings and epoxy resin for industrial tooling.	
U.S. Rubber Co.	2823
Vinyl sheeting laminated to steel and aluminum.	
Vaco Products Co.	2675
Miscellaneous hand tools.	
Vacu-Blast Co., Inc.	2719
Blast-cleaning equipment.	
Vanadium Corp. of America	343
Ferro-alloys, metals and chemicals.	
Vandersee Corp.	2408
Metallizing machines and accessories.	
Viking Drill & Tool Co.	532



Waldes Kohinoor, Inc.	2240
Retaining rings, pliers, assembly and accessory tools.	
Wales-Strippit Corp.	2405
Sheet metal fabricator.	
Wallace Supplies Mfg. Co.	2491
Duplicating bender and combination cutting and deburring machine.	
Watson-Stillman Press Div., Farrel-Birmingham Co., Inc.	2777
Waukeee Engineering Co., Inc.	2508
Flowmeters, gas-air mixers and industrial washing machines.	
Weatherhead Co.	2029
Industrial fittings and hose.	
Wells Mfg. Corp.	1912
Metal cutting band saws.	
Westinghouse Electric Corp.	1711
Vacuum melting furnace; welders; R F heating; fluoroscopic testing; alloys; motors and controls.	
Weston Electrical Instrument Corp.	2737
Electrical recording and controlling instruments.	
Wheelabrator Corp.	2380
New Wheelabrator super-tumbblast.	
Whistler & Sons, Inc., S. B.	2014
Magnetic and universal adjustable perforating equipment.	
Wilson, Inc., K. R.	2407
Wilson Mechanical Instrument Div.	1211
Rockwell and Tukon hardness testers.	
Wilton Tool Mfg. Co., Inc.	808
Vises and work positioners.	
Yale & Towne Mfg. Co.	915
Powder metal parts.	
Zaco Laboratories	1219
Colored paint for metal identification.	
Zagar Tool Inc.	2752
Collets and drilling equipment.	
Zeiss, Inc., Carl	2522
Microscopes and metallographic equipment.	

Economic Atomic Power Depends on Materials of Construction

By JOHN H. FRYE, JR. and JAMES L. GREGG*

If metallurgists, ceramic engineers and chemists can produce the necessary constructional materials and low-cost uranium refining methods, a breeder reactor using uranium isotope 233 and a thorium blanket can generate heat at costs comparable to steam boilers using coal. (T25, U, Th, Al, Zr)

IT HAS BEEN clear for some time that electrical power can be produced in nuclear reactors of several different designs. There is not space to discuss all of these possibilities in this article; merely to list them taxes the limits of the data sheet, p. 96-B. Furthermore, many of the features are still "classified" information. Suffice it to say that, although the production of nuclear power is technically feasible and sizable power plants are under construction in England, the main problem is one of reducing costs to the point where the power is economically competitive with existing sources of energy. Even though this means that the Englishman or the Alaskan will have a different view of the proposition from the Pennsylvanian or the Texan, since the economics (principally cost and availability of adequate coal or fuel oil *at the site*) differ markedly at various places on the earth, we will attempt to show how the major problems lie in the field of materials, and are therefore of particular interest to the metallurgist. We hope this article will give the reader some insight into the materials and materials-handling costs involved in producing economical power from uranium. We shall say nothing about capital and operating costs, important though they are.

Fortunately for our purpose, there is one reactor that has operated reliably since early in 1952, and for which the costs are known in some

detail and which can be discussed rather fully without violating security requirements. This reactor is the Materials Testing Reactor in Idaho, the so-called M.T.R. It operates at a low temperature — below the boiling point of water — and is used for testing purposes and not for power production. Nevertheless, it could be converted to power production without any major change in the cost of the raw materials or for their fabrication and reprocessing. Therefore, a study of this installation gives real insight into the problem of nuclear power.

Furthermore, reactors of this type are of great importance because they are concentrated sources of energy. For example, in one cubic yard of space one can easily produce 100 million watts of heat (roughly 130,000 hp. continuously, at 100% conversion into power) and continue to do so for two months without replenishing the uranium being fissioned! When the fuel must be replaced, the total weight of uranium and container is of the order of a ton; whereas, if coal were used, several thousand tons would be required. Thus, such reactors are important for power production in remote and

*John H. Frye, Jr., is Director of the Metallurgy Division of Oak Ridge National Laboratory, and James L. Gregg is Professor of Metallurgical Engineering at Cornell University and consultant to Oak Ridge National Laboratory.

inaccessible regions and for the propulsion of various large vehicles and sea-going vessels.

The M.T.R. is normally operated at a power level of 40,000 kw.* Fuel is the uranium isotope having a mass of 235, normally designated U²³⁵. For each gram of fuel fissioned, approximately one megawatt-day or 2.4×10^4 kw-hr. of energy in the form of heat is released. The reactor, therefore, "burns" approximately 40 g. of U²³⁵ per day.

In preparing the fuel, uranium is alloyed with about five times its weight of aluminum, poured into small ingot molds and rolled down to 0.25-in. plates. Small square wafers are then surrounded on all sides by aluminum, and this whole "picture-frame" assembly rolled into slightly dished sheets 0.06 in. thick, 3 in. wide, and 26 in. long. These are assembled and brazed into the fuel unit shown in the photograph. Each end is closed by a hollow aluminum casting which can enter corresponding holes in "tube sheets" at each end, thus accurately spacing each rectangular unit so it clears its neighbors by about the same distance as that between the curved plates. Heat is extracted from these units by pumping water through them. If they were clad with some metal with better high-temperature properties than aluminum, such as steel or a nickel-base alloy, it would be possible to operate the M.T.R. at temperatures high enough to produce useful power, but for developing the argument we will assume that aluminum can be used at such higher temperatures. If we analyze the costs of the materials involved in power production, these costs should not be altered drastically by the use of steel in the place of aluminum, and the results would give a fairly accurate picture of the cost of producing power from the fissioning of U²³⁵.

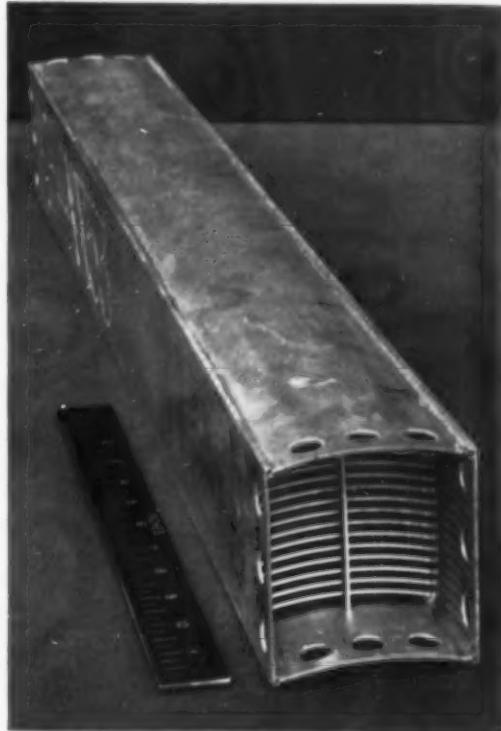
Elements of Cost

The uranium metal used as fuel in the M.T.R. is "highly enriched", meaning that it contains at least 90% of the isotope U²³⁵. (Natural uranium, as is well known, contains 99.3% U²³⁸ and only 0.7% U²³⁵.) While the actual cost of U²³⁵ in this enriched uranium cannot be ascertained, it has been variously estimated at \$15 to \$30 per gram. The cost of fuel per kw-hr. of heat would then be between 0.6 and 1.25 mills. If thermal energy can be converted to electric energy at an efficiency of 25%, the fuel costs

*That is, produces 40 million joules of heat per sec., equivalent (again at 100% conversion into power) to 53,500 hp.

would be between 2.5 and 5 mills per kw-hr. of electricity. In comparison, the cost of coal burned in a steam plant in this country will range from 2 to 5 mills per kw-hr. of electricity produced, depending on the cost of the fuel delivered to the plant and on the efficiency of converting thermal to electric energy in that particular plant.

In addition to the actual cost of fuel burned, there are other costs in connection with reactors that are not encountered in coal-burning steam plants. In order to use the uranium in the M.T.R., it is alloyed with aluminum, rolled into plates, and then clad with aluminum. Eighteen of these plates are then brazed to side plates to form the fuel element shown in the photograph. Each fuel element contains approximately 200 g. of U²³⁵ and the cost of fabricating a single fuel element has been estimated to be between \$300 and



Fuel Element Devised at Oak Ridge National Laboratory for the Materials Testing Reactor in Idaho. It consists of parallel plates - 0.020-in. sheets of uranium-aluminum alloy clad with 0.015 in. of pure aluminum. The uranium has at least 90% of the fissionable isotope U²³⁵. This type of fuel element has been used in a dozen or more test reactors constructed since 1952

\$600 or \$1.50 and \$3.00 per g. of uranium. When only 25% of the U²³⁵ has fissioned ("burned"), the fuel element must be replaced.* The fabrication cost per gram of uranium actually consumed is, therefore, four times the values given above, or between \$6.00 and \$12.00 per g. At an efficiency of 25%, this fabrication cost would amount to between 1 and 2 mills per kw-hr. of electricity.

The remaining uranium in each element must then be separated from its fission products and recovered for reuse. This is usually done by dissolving the entire assembly in dilute nitric acid, and then separating chemically the aluminum, fission products and uranium. The fuel element from the reactor is highly radioactive, and the element as well as the solution resulting from its dissolution must be kept behind heavy shields. The handling of highly radioactive materials is inherently expensive, due to the necessary equipment for remote control and protection of personnel, and the cost of chemical processing may be assumed to be in the range of \$1.00 to \$5.00 per g. of uranium processed. As 3 g. of uranium must be processed for each gram burned, the cost per gram of uranium burned will be between \$3.00 and \$15. Again assuming an efficiency of conversion, heat to power, of 25%, the processing cost of recovery would be between 0.5 and 2.5 mills per kw-hr. of electricity.

The real fuel costs in mills per kw-hr. of electricity generated from a plant like the M.T.R. might then be assumed to be within the range shown below. In addition to these costs, there is the cost of disposing of radioactive wastes and the inventory costs on fuel. Together, these might add from 0.1 to 0.3 mill per kw-hr. of electricity.

	LOW	HIGH
Cost of U ²³⁵ burned	2.5 mills	5.0 mills
Fabrication	1.0	2.0
Chemical processing	0.5	2.5
TOTAL	4.0 mills	9.5 mills
Coal	2 mills	5 mills

Costs in the range indicated may be allowable for military reactors and for reactors used for research and testing, but are too high to manufacture power in America, where we still have vast reserves of unmined coal. Fortunately, there are definite possibilities of lowering the real cost of fuel to a value that will make it at least competitive with our fossil fuels.

*It has been reported that the elements are now operated to a burnup of 40%.

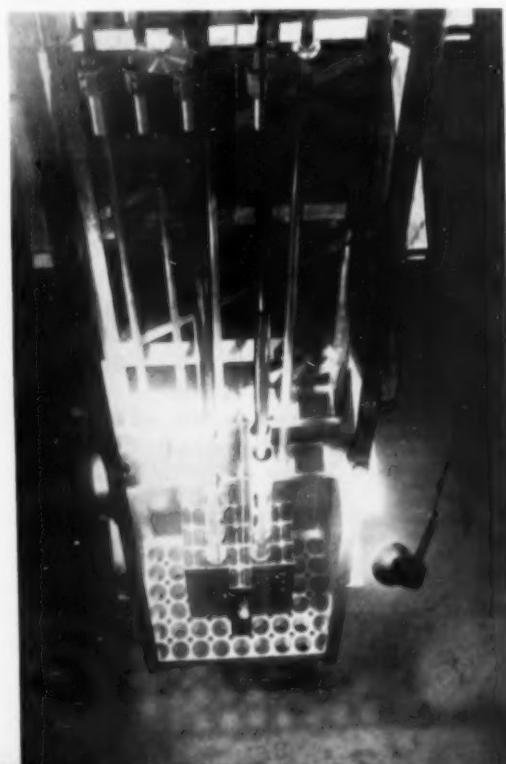
Thorium for Breeding

One possibility is to use the excess neutrons which form during fissioning (that is to say, the excess over those required to perpetuate the chain reaction and those unavoidably lost, strayed or stolen) to produce new fissionable atoms, thus having a reactor that *makes* fuel about as fast as it burns fuel. Certain types of reactors produce as many new fissionable atoms as are consumed. It is common to speak of this as "breeding".

In the M.T.R., each ten atoms of U²³⁵ consumed produces 21 neutrons, on the average. If we used U²³³ (that is, the uranium isotope of mass 233) instead of U²³⁵, the same energy would be released per fission, and we would obtain 23 neutrons for every ten atoms of U²³³ consumed. In either case ten of the neutrons must be used to fission the next ten atoms of U²³³ or U²³⁵ in order to keep the reactor operating. Some of the surplus could be used to produce U²³³ from thorium. Let us see how this might be done.

When an atom of thorium captures a neutron, it transforms into an atom of U²³³. Thus, if we could design a reactor using U²³³ so that ten out of each 13 excess neutrons were captured by ten thorium atoms, we would produce in the thorium blanket or shield a new atom of U²³³.

"Swimming Pool" Research Reactor, Such as This One at Penn State University, Uses Open-Ended Fuel Elements of Plate Type, and Water as a Coolant and Radiation Barrier



for each atom of U^{233} consumed in the fuel element. Let us assume that we are able to design such a reactor.

The cost of power would then be greatly reduced, as can be seen by the following table:

	LOW	HIGH
Cost of U^{233} burned	0.2 mills	0.8 mills
Fabrication	1.0	2.0
Chemical processing	0.5	2.5
TOTAL	1.7 mills	5.3 mills
Coal	2 mills	5 mills

The cost of fabricating and of chemically processing the fuel units should be roughly the same for either U^{233} or U^{235} . However, the cost of burning U^{233} is much less than that for burning U^{235} . This represents the sum of the original cost of the thorium metal converted plus the cost of removing the U^{233} from the mass of unchanged thorium in which it is produced. The first is negligible; only the second need be considered.

Here we will assume that the cost of chemically removing U^{233} from thorium is the same as for removing U^{235} from the fabricated fuel elements. We will also assume that the thorium should be processed when the uranium content reaches 0.2 to 1%. On this basis, U^{233} will range in cost from \$1.00 to \$5.00 per g. as against \$15.00 to \$30.00 per g. of U^{235} .

The tabulation above shows that the total estimated cost of power in a breeder reactor should range from 1.7 to 5.3 mills per kw-hr., and this compares favorably with costs of 2 to 5 mills in a coal-fired steam plant. The nuclear fuel costs are necessarily rough approximations, but they do make one thing quite clear, namely:

The cost of fuel is almost entirely dependent on the cost of metallurgical fabrication and chemical processing.

If and when the metallurgists and chemists can reduce their costs to very low levels, nuclear fuel will be in a position to replace coal for the production of electrical power, even in the United States, where we have comparatively cheap coal.

A Practicable Power Plant

The figures presented in the second table indicate that, given a thermal efficiency of 25% and a breeding system, nuclear power should be competitive with coal power in the United States. Aluminum is suitable to contain the uranium and fission products in a breeding reactor because it captures very few neutrons, but it must be used at such low temperatures that the

efficiency of the conversion of heat to power would be intolerably low. The only metal which does not capture so many neutrons that a breeding system could not properly operate and which can be used at reasonably high temperatures is zirconium. Thus, if zirconium were substituted for aluminum in the well-tried elements of plate form, it would be possible to have a breeding reactor which can operate and produce power in quantity. We shall, therefore, consider the economics of such a reactor.

A system which has been demonstrated to be practicable uses pressurized water as a heat-transfer medium. In this system, water is heated to the neighborhood of 600° F. by solid fuel elements in the core of the reactor. This hot water goes to a heat exchanger where it generates steam. This steam, in a secondary circuit, drives a conventional turbine.

The first disadvantage of this system is that it cannot operate at as high a thermal efficiency as a conventional power plant that uses steam at 1100° F. This automatically increases the cost of the electricity since, for a given cost of heat, the cost of electricity varies as the reciprocal of the efficiency of conversion of heat to electricity. If the costs of fabrication and of chemical processing can be kept sufficiently low, however, the decreased efficiency will not be the ruling factor.

We return again to the second table to discuss these costs. The cost of U^{233} is not altered by substituting zirconium for aluminum. The cost of fabrication will definitely be increased, because zirconium is much more expensive than aluminum and is much more costly to fabricate. Although actual figures cannot be given, it is probably impossible for such a reactor to compete with cheap coal today.

There are some power reactors now in operation, others in course of construction, and a number of reactor systems under investigation in this country, not only by governmental agencies but by private industry. (See the data sheet, p. 96-B.) These systems and the materials problems involved in them have recently been discussed in some detail in a special report on nuclear metallurgy by the Institute of Metals Division of the American Institute of Mining, Metallurgical and Petroleum Engineers. Suffice it to say that in all of these schemes the limiting factors lie in the fields of chemistry, ceramics and metallurgy. Not only is it important to keep down the chemical and fabrication costs, but in some systems there are the added factors of

durability and reliability of materials under existing conditions of corrosion and radiation. In certain systems which appear very attractive on paper, the localized temperatures and radiation intensities are beyond the capacity of available metals fabricated in conventional ways, and their practicability will depend upon whether proper ceramic or ceramic-metal compositions can be formulated and fabricated. Even these factors can be expressed in economic terms, since they either shorten the life of expensive equipment or require more frequent chemical and metallurgical processing.

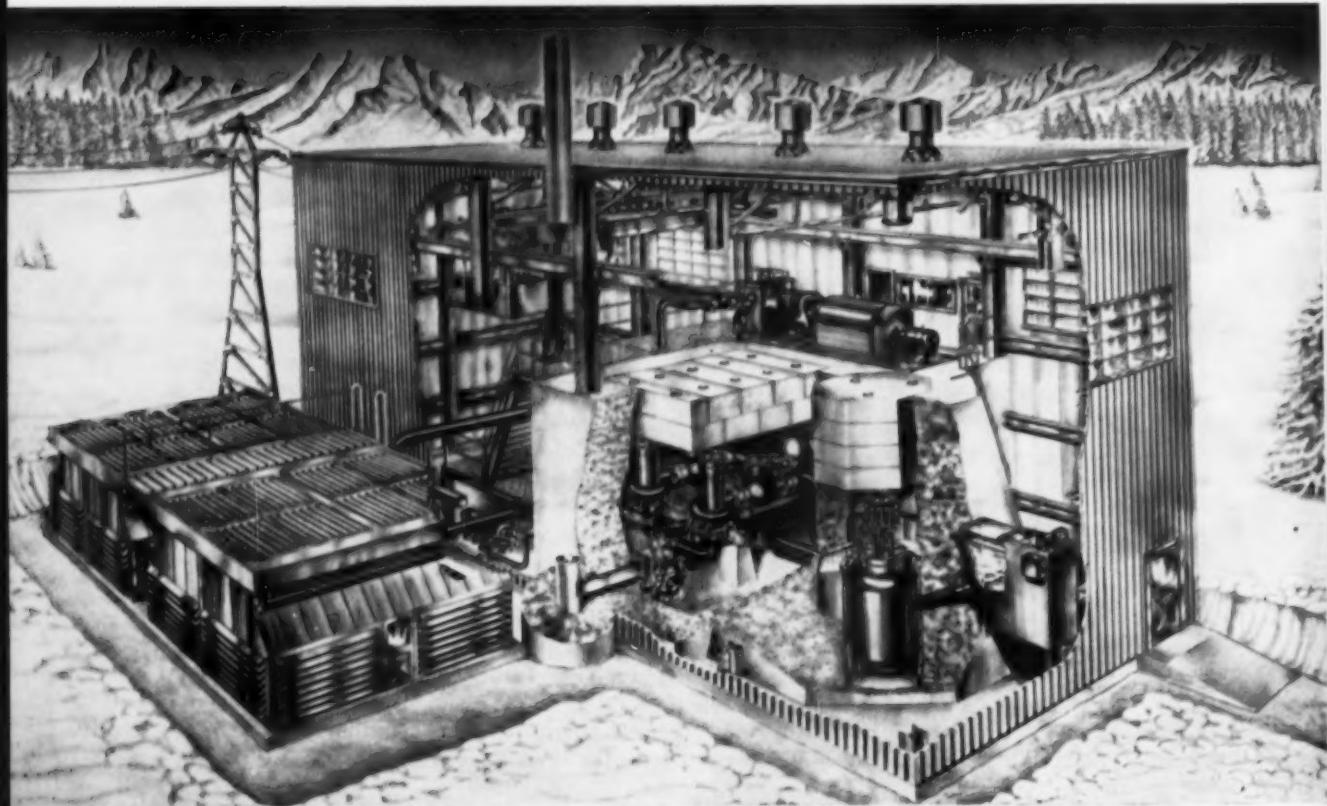
Package Power Reactor

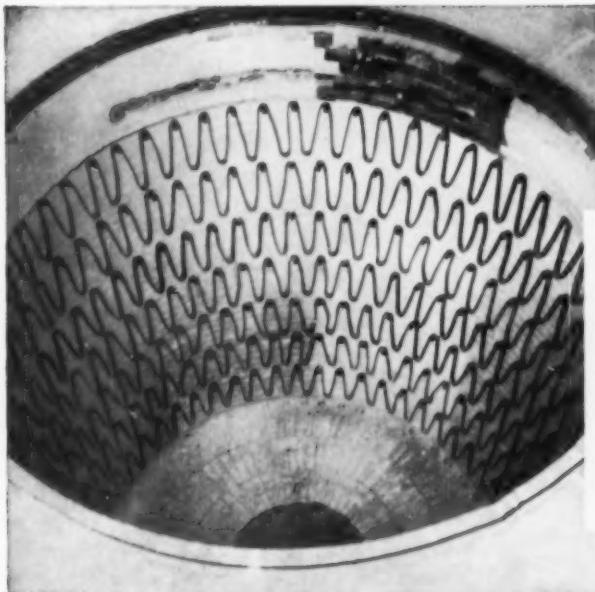
The kind of reactor discussed in this article — a reactor using solid fuel elements which transfer the heat they generate to surrounding water — is quite well suited to power production in remote locations and to the propulsion of large vehicles. It is, therefore, an important kind of reactor and well worth study. In addition, certain conclu-

sions, which can be drawn about this class of reactors, are generally applicable. They are:

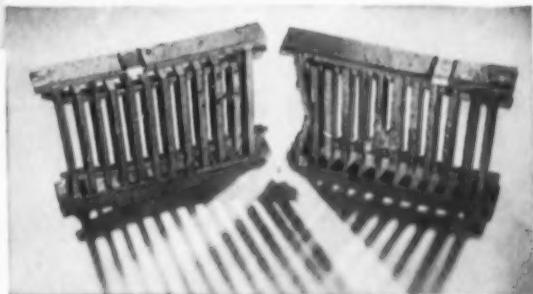
1. Electricity can be produced reliably by nuclear reactors.
2. The question of how extensively and how soon nuclear power will replace coal power is an economic one.
3. In much, if not all, of the United States it is cheaper to use coal than enriched U²³⁵ as a fuel, and there is no reason to expect this situation to change in the near future.
4. It is not necessary to use U²³⁵ as a fuel if a breeding reactor is used. For example, U²³⁸ can be burned in the core and replaced by U²³³ bred in a surrounding blanket of thorium.
5. Such a reactor can produce electricity more cheaply than a coal-fired plant if costs of metallurgical fabrication and chemical processing can be kept sufficiently low.
6. Thus, the future of nuclear power in this country rests primarily in the hands of metallurgists, ceramic engineers and chemists. ☐

Design Study of "Package" Power Reactor for U.S. Army Made by Oak Ridge National Laboratory. Reactor and controls in near corner, heat interchanger below floor slabs at center, turbo-generator set above, and "cooling tower" at left





This Vacuum Retort was used at Pacific Northwest Alloys, Inc., Spokane, Washington, for producing low carbon ferrochrome. Temperature was held at over 2175°F. for several days during production cycles. Atmosphere, primarily carbon monoxide, contained some metal vapor at an absolute pressure that varied from one inch to 100 microns of mercury. During 10 production runs, INCO Engineers tested a variety of heat-resistant alloys in this furnace.



Inco finds answers to High-Temperature Problems in plant tests

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INCO has tested scores of metals and alloys at elevated temperatures, in plant operations of all sorts. These tests have yielded information on the relative resistances to scaling and corrosion, as well as on other pertinent properties of the materials tested . . . under high temperatures in many diverse atmospheres.

Which Alloy Will Perform Best? Racks like these, often help to determine exactly the right metal for a specific application. Various cast and wrought alloys were assembled on the two racks, and placed in the retort, shown above, for 10 production cycles. One of the specimens under test was practically immune to corrosion with a loss of only .006 ipy. Average corrosion rates in inches penetration per year for the other specimens ranged from .015 to .153 inches.

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Power Reactor Programs in the U. S.

LINE	REACTOR AND OWNER (a)		LOCATION	OUTPUT; KW.		FUEL		
				HEAT	POWER	AMOUNT	ENRICHMENT	
Major Experimental Power Reactors in the Atomic Energy Commission's Program								
A	EBR-1	Argonne	Idaho	1400	150	48 kg. U	90 % ±	
B	EBR-2	Argonne	Idaho	62,500	17,500	90 kg. Pu + 150 kg. U	45 %	
C	HRE-1	ORNL	Oak Ridge	1000	150	3 kg. U	90 % ±	
D	HRE-2	ORNL	Oak Ridge	Up to 10,000	300	4 kg. U	90 % ±	
E	BORAX-3	Argonne	Idaho	15,000	2400	15 kg. U	90 % ±	
F	EBWR	Argonne	Argonne	20,000	5000	4500 kg. U	1.4%	
G	SRE	N.A.A., Inc.	Sta. Susanna	20,000	7500	2100 kg. U	2.9%	
H	LAPRE-1	Los Alamos	Los Alamos	2000		8.4 kg. U	90 % ±	
I	LAPRE-2	Los Alamos	Los Alamos	1300		7.7 kg. U	90 % ±	
J	LAMPRE	Los Alamos	Los Alamos	1000		Molten plutonium alloy		
K	OMRE	N.A.A., Inc.	Idaho	16,000		20 kg. U	90 % ±	
Prototype Power Plants to Be Financed Primarily by American Industry								
L	Westinghouse and Duquesne Power Co.	Shippingport	235,000	100,000±	12 tons natural U	45 kg. U ^(a)		
M	Consumers Public Power District	Nebraska	250,000	75,000	24,800 kg. U	1.8%		
N	Yankee Atomic Electric Co.	Massachusetts	500,000	134,000	25,500 kg. U	2.7%		
O	Detroit Edison and Associates	Michigan	300,000	100,000	2100 kg. U	20 %		
P	Commonwealth Edison and Associates	Illinois	680,000	180,000	68,000 kg. U	1.1%		
Q	Consolidated Edison	New York	500,000	250,000(f)	275 kg. U	90 % ±		
R	Westinghouse and Penn Power & Light	Pennsylvania		150,000		Homogeneous reactor		
"Second Round" in the Power Demonstration Program								
S	Chugach Electric Assoc., Alaska	Anchorage	40,000	10,000	10,000 kg. U	2 % ±		
T	Wolverine Electric Cooperative	Michigan	15,700	10,000(i)	12 kg. U	90 % ±		
U	University of Florida	Gainesville	10,000	2000		35 % ±		
V	City of Orlando, Florida	Orlando		<40,000	67 kg. U	90 % ±		
W	Rural Cooperative Power Assoc.	Minnesota	58,000	22,000	10,000 kg. natural U	1.2%		
X	City of Piqua, Ohio	Piqua	45,500	12,500	6300 kg. U	3 %		
Y	City of Holyoke, Mass.	Holyoke	44,000	15,000	70 kg. U	5 %		
LINE	MODERATOR	COOLANT			COSTS		COMPLETION DATE	
		NATURE	TEMP° F.	PRESSURE (b)	REACTOR (c)	TOTAL PLANT	PER KW.	
Major Experimental Power Reactors in the Atomic Energy Commission's Program								
A	None	NaK	600	100	2,700,000	3,300,000 (d)		1951
B	None	Na	1000	100	15,300,000	39,600,000 (d)		1959
C	H ₂ O	Fuel solution	480	1000	1,100,000	9,700,000 (d)		1953
D	D ₂ O	Fuel solution	570	2000	1,800,000	38,800,000 (d)		1956
E	H ₂ O	H ₂ O	420	300	600,000			1955
F	H ₂ O	H ₂ O	490	600	2,600,000	9,700,000 (d)		1956
G	Graphite	Na	960	300	4,900,000	13,400,000 (d)		1957
H	H ₂ O	Fuel solution	800	3900±	700,000	2,200,000 (d)		1956
I	H ₂ O	Fuel solution	600	800±	100,000	280,000 (d)		1956
J	None	NaK				3,000,000 (d)		1959
K	Diphenyl	Diphenyl	530	300	875,000	1,800,000 (d)		1957
Prototype Power Plants to Be Financed Primarily by American Industry								
L	H ₂ O	H ₂ O	540	2000	37,700,000	47,700,000	750±	1957
M	Graphite	Na	925	300	13,500,000	24,300,000	320	1959
N	H ₂ O	H ₂ O	400	900	19,300,000	26,000,000	195	1960
O	None (e)	Na	800	<200	45,000,000	54,000,000	540	1960
P	H ₂ O	H ₂ O	480	600	34,200,000	45,000,000	250	1960
Q	H ₂ O (g)	H ₂ O	500	1500		55,000,000	230	1960
R		Fuel solution			Privately financed			1962
"Second Round" in the Power Demonstration Program								
S	D ₂ O	Na	950	1 atm.	5,500,000 (h)	7,350,000	735	1961
T	D ₂ O	Fuel solution	570	2000	2,500,000	3,575,000	357	1959
U	H ₂ O	H ₂ O	450	1200	1,400,000	1,600,000	800	1959
V	Graphite (f)	Molten Bi-U alloy			12,500,000	20,500,000	510 to 820	1960
W	H ₂ O	H ₂ O	533	900	3,760,000	6,185,000	280	1960
X	Hydrocarbon	Hydrocarbon	620	30	3,340,000	5,300,000	425	1960
Y		N ₂	1290	515	2,400,000	6,430,000	430	1960

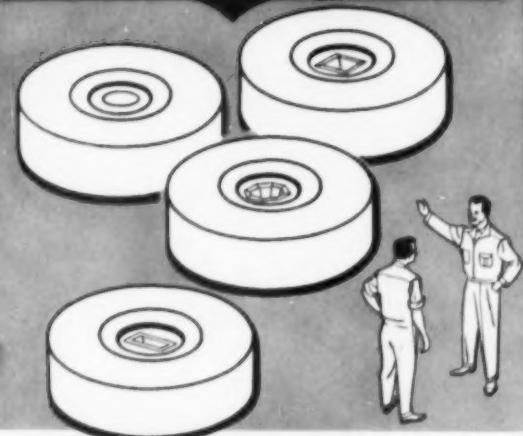
- (a) A responsible laboratory or contractor of U.S. Atomic Energy Commission.
 (b) Psi. gage.
 (c) Exclusive of cost of fissionable material.
 (d) Total cost of programs.
 (e) Fast breeder.
 (f) Includes 110,000 kw. from fuel-fired superheater.
 (g) Plus 8100 kg. thorium in blanket.
 (h) Exclusive of research and development.
 (i) About half from fuel-fired superheater.
 (j) Plus 17,000 lb. thorium in blanket.

BORAX: Boiling water experiment.
 EBR: Experimental breeder reactor.
 EBWR: Experimental boiling water reactor.
 HRE: Homogeneous reactor experiment.
 LAMPRE: Los Alamos molten plutonium reactor experiment.
 LAPRE: Los Alamos power reactor experiment.
 NAA: Atomics International (North American Aviation Co.).
 OMPRE: Organic moderated reactor experiment.
 ORNL: Oak Ridge National Laboratory.
 PWR: Pressurized water reactor.
 SRE: Sodium reactor experiment.

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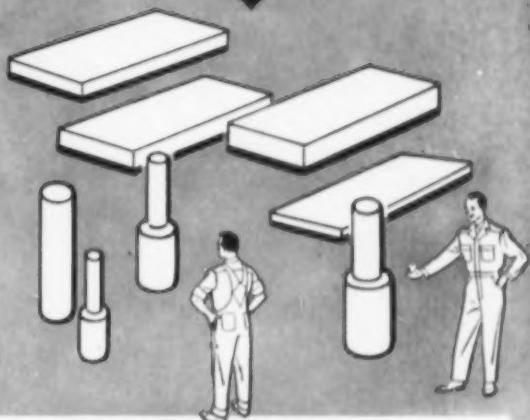
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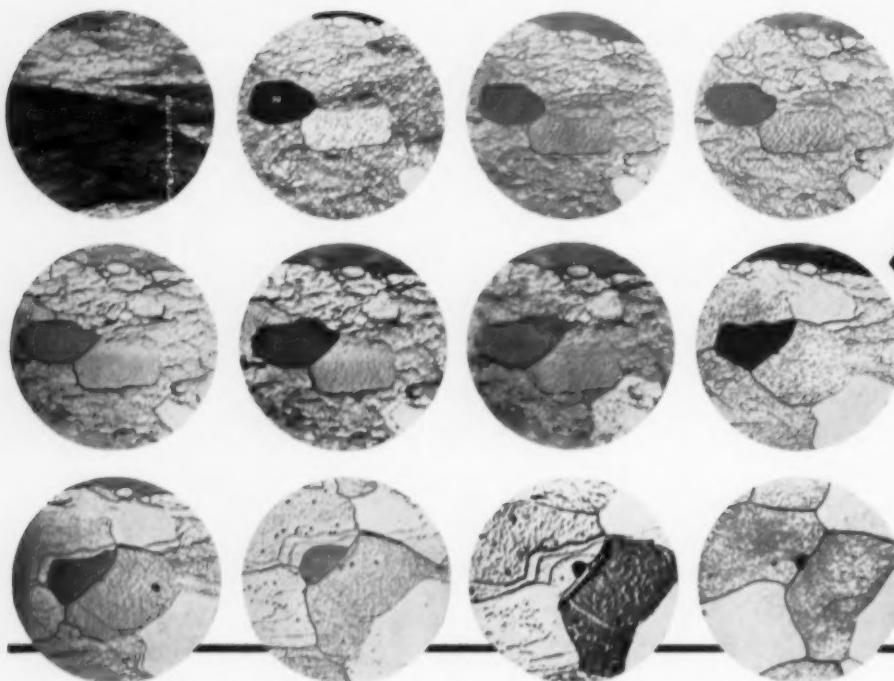
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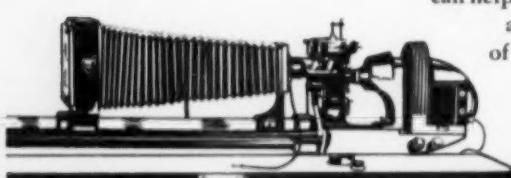
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Fig. 1 - 60-In. Coarse Crusher at E. W. Davis Works, Babbitt, Minn.

Magnetite Concentrates to Supplement High-Grade Iron Ore

By E. C. WRIGHT*

As the high-grade Mesabi mines are being mined out, concentration of low-grade ore is coming ahead. One plant will make 3,500,000 tons of 63% iron pellets in 1956; another twice as large is under construction. (B 13, B 14, B 16, Fe)

A PREDICTION of future consumption of iron and steel, based on past performance of American industry, economics and population, indicates that our present consumption of 120,000,000 gross tons of iron ore will rise to at least 150,000,000 tons annually by 1980.

Where are we going to get this much iron ore?

Let us examine the present sources. In round numbers the score in gross tons per year is:

From Lake Superior region	80,000,000
Other American regions	20,000,000
Imports	20,000,000

Imported tonnage is going up sharply — it doubled in the past two years — representing ore from Venezuela added to that from the older important exporters: Sweden, Cuba, Africa, South America. The figures will jump further



when the Canadian deposits in Labrador start shipping. However, firm reliance could not be placed on any of these in an emergency (except perhaps the Labrador deposits), as we learned to our sorrow in attempting to bring the needed 3,000,000 tons of bauxite across the Caribbean during each of the World War II years.

Stockpiling of imported iron ore to the tune of, say, 100 million tons does not appear to be possible, politically. That means that in any future war the iron and steel industry will have to fall back on local sources of ore and scrap.

*Head, Department of Metallurgical Engineering, University of Alabama, and Consulting Editor, *Metal Progress*. Especial thanks are due to Fred DeVaney of Erie Mining Co., and Oscar Lee of Reserve Mining Co. for courtesies extended during visits to the Iron Range.

General View of American Resources

What is the situation in the iron ranges, which have been shipping close to 80 million gross tons of ore down the lakes in each of the last 15 years? Iron ore was discovered in Minnesota a century ago; mining was slow in starting and the amounts shipped prior to World War I seemed puny in comparison with the astronomical amounts thought to be available. However, now — 1958 — there is less than a billion tons of direct-shipping, high-grade ores remaining up there — certainly less than 20 years' supply even at the present rate. The U.S. Bureau of Mines estimated in 1950 that the "measured, indicated, and inferred" amount of direct-shipping ore and ore amenable to simple washing processes totaled 3,600,000,000 in Minnesota, Michigan and Wisconsin — 40 years' supply at present rate of 80 million annually, a rate which can hardly be exceeded in the declining life of these ore bodies.

Nor can we depend upon known ore deposits in other parts of the United States. There is a good deal of it scattered about, but iron ore is like many bulk commodities — you can't haul it economically very far. Population (uses and users) must move toward a land-locked deposit of hematite before it becomes ore. Nevertheless, we can take a look at the 1950 estimates of "measured, indicated and inferred" ore (direct-shipping or easily concentrated):

Northeastern states	380,000,000	gross tons
Southeastern region	1,627,000,000	
Missouri and Texas	64,000,000	
Western region	484,000,000	
TOTAL	2,555,000,000	gross tons

This indicates a comfortable century ahead for that portion of our present scattered industry at its annual consumption of 20 million plus. It is the much larger fraction in the Midwest that depends on ore from the Lake Superior region which must do the worrying.

Fortunately for them there is a tremendous quantity of low-grade or marginal ores in that very region. The latest estimates by the U.S. Geological Survey and the Bureau of Mines (1950) show about 70 billion tons of rock containing 20 to 27% iron from which about 24 billion tons of concentrates containing 63% iron can be made. Of the latter, at least 20 billion tons can be made from the taconite rock of the Mesabi Range in Minnesota with about 1 billion from the hematitic jasper deposits of Wisconsin and Michigan. This could serve our expanding industry for over a century and is of course

worthy of the attention given it during the past five years.

Producers of nonferrous metals long ago reached the end of high-grade ores in America. For over 40 years they have recovered copper, zinc and lead from very lean and complex ores. Information as to operating processes and equipment for handling huge tonnages of low-grade ores was therefore available to the steel industry. Most of the practices and engineering equipment necessary for fine grinding of iron ore, and classifying, filtering, and agglomerating the fine concentrates, were developed long ago by nonferrous metal producers and many were readily adaptable to the beneficiation of marginal-grade iron ores.

The first engineer who realized the great potential of the taconite deposits was from the nonferrous metal industry — W. C. Swart, prominent in the development of large deposits analyzing about 1% copper. This was nearly 40 years ago. Working with E. W. Davis, director of the Mines Experiment Station at the University of Minnesota, he attempted to concentrate the magnetic taconites at Babbitt, Minn. Although this early work did not produce a marketable product at a competitive price, it explored many problems encountered in taconite mining and processing; Davis continued the studies at Minnesota and for 30 years has warned of the rapid depletion of the direct-shipping ores — for most of the time a voice in the wilderness.

The critical iron ore situation outlined in preceding paragraphs finally was realized after World War II. Development of foreign deposits and taconite pilot plants was suddenly intensified. What follows will be a necessarily brief account of the present status of the latter efforts.

Concentration of Magnetite

The term taconite refers to siliceous iron-bearing formations more than 100 miles long in the Mesabi Range in northern Minnesota. The western end contains iron oxide, mostly as hematite, totaling about 50 billion tons of low-grade ore; 5 to 6 billion tons at the eastern end contains most of the iron as magnetite. The chemical and physical structure of these rocks varies widely, and iron occurs as hematite, magnetite, siderite, limonite, and as silicates. Beneficiation processes must therefore be adapted to the type of deposit being worked.

Intensive laboratory research performed over the past ten years has shown that several different processes will have to be developed and carried

through the pilot plant stage before an appropriate plant can be built.

As far as is known at present, the most easily worked taconites contain magnetic oxide. The two largest full-scale plants now work these exclusively, by fine grinding through 100 mesh with magnetic separation of the mineral magnetite. Two other methods offer promise of eventual success at other places: (a) froth flotation of specular hematite in the ferruginous sandstones of the Marquette district of Michigan, and (b) reduction roasting of Mesabi hematitic taconite or Michigan jasper to produce an artificial magnetite for magnetic separation. Since the last-mentioned ores represent the largest reserves, they will be most important, potentially. Furthermore, they will require the greatest amount of research effort. The flotation process, which is so successful for sulphide ores of copper, lead and zinc, is not too efficient or economical on oxidized iron ores except the specular hematites of Michigan. The large proportion of material to be floated (30% as against 1 to 3% of the sulphide ores) also consumes a very high amount of costly reagent.

Operating plants on the magnetic taconite include a large one at Silver Bay, Minn. (Reserve Mining Co.). It has been operating for several months at the rate of 3,750,000 tons of concentrates per year. Erie Mining Co. has operated a pilot plant for several years near Aurora, Minn., producing 200,000 tons annually; from experience so gained a commercial plant for 7,500,000 tons of concentrates per year is now being constructed. Oliver Iron Mining Co. has studied taconite for many years, at first in a large laboratory in Duluth, and is currently processing over 800,000 tons annually in a pilot plant at Pilotac near the village of Mountain Iron, Minn.

Some of the more important difficulties to be hurdled were:

1. Mining the dense, hard taconite rock.
2. Coarse crushing of boulders sometimes 4 ft. in diameter.
3. Fine grinding to under 100 mesh.
4. Magnetic separation.
5. Agglomeration of the very fine concentrate into a form suitable for shipping and satisfactory for blast furnace operations.
6. Full-scale tests of the blast furnace feed at different steel plants.

The hard-rock mining problem which stymied the early enterprise at Babbitt, 40 years ago, has been overcome by the "jet piercer" of Linde Air Products Co., which uses oxygen to burn a

blast hole at the rate of 18 to 20 ft. per hr. The blasted chunks are then crushed in huge gyratory crushers handling up to 4000 tons per hr. Fine grinding is in two stages: first to about 8 mesh in rod mills with classifiers and magnetic separators in closed circuit, followed by ball mills, classifiers and magnetic separators down to 80% through 320 mesh. The combined concentrates have little tendency to slime and are filtered to a cake which contains 8 to 10% water. The mined ore at Aurora contains from 18 to 25% iron as magnetite. The yield of concentrate averages 33% of the feed which requires the mining of three tons of taconite for one ton of concentrate. The analysis of the concentrate ranges from 61.5 to 64% iron with 7 to 9% SiO₂, and figures to a recovery of about 94% of the magnetite in the ore. Very similar figures were reported at the Reserve Mining plant at Silver Bay.

Considerable difference in practice beyond this point is evident at the various taconite plants and laboratories.

Fig. 2 — Looking East in Concentrator Building of E. W. Davis Works at Silver Bay, Minn., Showing Hydro and Magnetic Separators



Pelletizing

Despite much study and work by equipment manufacturers, there is still a large amount of discussion and difference of opinion about pelletizing. The fine concentrates cannot be sintered on a traveling grate without high dust loss. The wet concentrate must be formed into small balls or pellets in a rotating drum by adding about 0.5% of Wyoming bentonite for binder. Erie Mining Co. adds about 16 lb. of fine anthracite which is milled in the feed and makes $\frac{1}{2}$ -in. pellets. In the Reserve Mining Co.'s mill the wet pellets, about 0.4 in. or more in diameter, are rerolled in another drum and coated with about 30 to 40 lb. of coal per ton. (This coal supplies part of the heat required for the heat hardening of the pellets.)

Another method of forming balls is practicable but is still in the development stage. It is illustrated in Fig. 3. The rotating saucer or "ball well" makes any desired ball size and avoids most of the recycling. The most favorable size of pellet is also a debatable subject.

Hardening of Pellets

Thousands of laboratory and pilot-plant tests have been made to find the best method and furnace for hardening the wet pellets so they can withstand weathering in stockpiles, shipping long distances, rough handling, low dust loss, and smelting without disintegration. From this work and Swedish practices, it is now generally agreed that the pellets should be fired to 2300 to 2400° F., in a vertical shaft furnace or on a traveling grate. The heat required per ton varies from 700,000 to 2,000,000 Btu., depending on the furnace and also on whether the Fe_3O_4 in the pellets is oxidized to Fe_2O_3 . This matter is important in a district where all fuels are costly — on the order of 60 to 75¢ per million Btu.

Four types of furnaces have been studied and the estimated heat requirements are as follows:

Rotary kiln nodulizing	2,000,000 Btu.
Open-top downdraft sintering machine	1,000,000
Closed-top recuperative traveling grates	1,300,000
Shaft furnace	750,000

The large plant of Reserve Mining Co. at Silver Bay has six recuperative traveling grates, each producing more than 2000 tons of fired pellets per day. These units were designed after several years of cooperative work by Reserve Mining Co., Allis-Chalmers, and Arthur G. McKee Co.

in a pilot plant at Carrollville, Wis. The machine has a traveling grate 6 ft. wide and 170 ft. long; the pellet bed is 9 to 12 in. deep. The drying, preheating, and firing sections are completely enclosed; there are 28 separate wind boxes under the grates and six stacks on each machine, which permits both downdrafting and updrafting, with recuperation of hot gases from the firing and cooling sections for drying and preheating the wet pellets. While pellets are heated to over 2300° F., the magnetite is not completely oxidized to Fe_2O_3 . They are then cooled to below 500° F., in a downdraft air cooler, and water sprays then quench the pellets on conveyors to the stockpile or ore boats. This is a well-engineered clean installation and a beautiful example of automation in the many control instruments which regulate the feeding, grate speed, and temperatures in the various stages.

E. W. Davis had studied the vertical shaft furnaces in experimental units at the University of Minnesota for many years. Likewise, engineers at Erie Mining Co. investigated the shaft furnace in their research laboratory at Hibbing. Many difficulties were encountered; the pellets would begin to fuse at 2450° F., uneven distribution of air caused hot spots and channeling; pellets stuck together in clumps or clusters which could not be discharged, and a round shaft appeared unsatisfactory.

The outcome of this work resulted in a rectangular furnace, 6 × 14 ft. in cross section and about 50 ft. high. On both sides of the wide section are combustion chambers from which enough fuel oil is injected into the bottom of the shaft to raise the temperature to about 1850° F. The hot gases are withdrawn and re-enter the main shaft 6 to 8 ft. below the top, and dry the bed of wet pellets as they descend into the firing zone. Excess air blown into the bottom cools the hot charge and then supplies oxygen for the coal in the pellets and to oxidize the Fe_3O_4 to Fe_2O_3 (an exothermic reaction which, by the way, supplies over 40% of the total heat requirements). In contrast to the $\frac{1}{2}$ -in. Reserve Mining pellets, which are mostly magnetite, the Erie pellets are mostly hematite and 1 in. in diameter. The shaft furnace fires 1000 tons of pellets per day; two of them have produced more than 1,000,000 tons in the past seven years.

About 3.5 gal. of light fuel oil per ton is burned, and the over-all thermal efficiency is much higher than in the other types. By close control of the maximum firing temperature (2400° F.) and the amount of air blown,

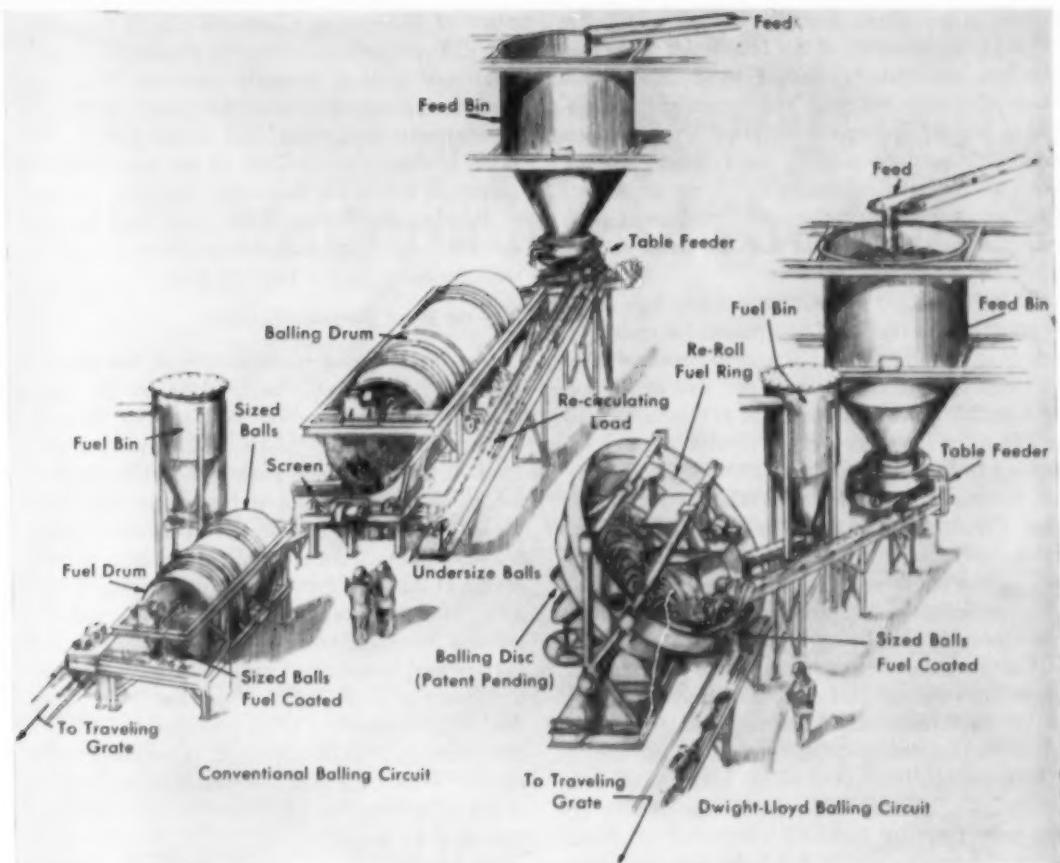


Fig. 3 – Conventional Balling in Drums as Compared With Dwight-Lloyd "Ballwell Balling Disk". Courtesy McDowell Co., Inc.

incipient fusion and cluster formation are controlled. A water-cooled shaft and cross arms in the bottom of the furnace break up any clusters.

This shaft furnace is a highly efficient and smoothly operating piece of metallurgical equipment. It is not too much to say that the furnacing problem had to be successfully solved before the firm could go ahead with the construction of the \$300,000,000 concentration plant near Aurora.

Concentration of Hematite

Most of the present developments are based on the magnetic taconite. Plants now erected or under construction can operate for more than 50 years on the magnetic ores and reach an annual output of more than 15,000,000 tons of this high-grade concentrate. It can be seen, therefore, that this source can supply all or a major fraction of the domestic ore needed during the next few decades to supplement the dwindling supply of high-grade shipping ore from the Mesabi.

Most of the taconite deposits of the Mesabi

Range contain hematite rather than magnetite. A further 3 billion tons of jasper, taconite, and ferruginous cherts are located in the Michigan-Wisconsin iron districts. Most of this contains 30 to 35% iron and cannot be concentrated by magnets in its natural state. Although large sums have already been spent studying these marginal ores, the results have been generally unfavorable technically and economically. Since the iron-bearing minerals are in very fine particles (under 100 mesh), extremely fine grinding is necessary to liberate them. Flotation is the only known process to handle such finely ground pulps. Much work with a wide variety of flotation reagents has yielded discouraging results (with one exception) so the whole problem of how to process the enormous reserves of hematitic low-grade ores still remains unsolved.

The one exception is a full-scale plant of the Cleveland-Cliffs Co., near Ishpeming, Mich.,

where a deposit of specular hematite is being mined in an open pit at the Humboldt Mine and the ore successfully floated to a concentrate containing over 60% iron. Since most of the high-grade direct-shipping ore produced in this region comes from deep underground mines, mining costs are high and operators in this region believe that concentrating costs on low-grade ores from an open pit might be less than the extra mining costs underground.

This Humboldt concentrator started in 1954. It contains conventional equipment for crushing, grinding, flotation, and filtering to produce 2000 or more tons of concentrate per day at a ratio of 1 to 2.33. Concentrates with 60% iron and 10 to 12% silica have been shipped without agglomerating to Ford Motor Co. in Detroit where they are sintered after mixing with other ores and flue dust. Construction of a similar plant at Republic, Mich., containing two additional flotation lines will give a combined daily output of about 7000 tons. Pelletizing and traveling grate sintering machinery is also being erected.

The specular hematite in these ores has a plate-like structure, an odd characteristic which makes the form amenable to simple flotation with a low reagent consumption. Only 1 lb. per ton of a mixture of fatty acids (oleic and linoleic) is consumed; for successful results the density of the pulp must be carefully controlled at about 40% solids, and the pH held closely within 6.9 to 7.1 limits.

Pelletizing and firing of the hematitic concentrate presented special problems which had to be overcome. Working closely with McDowell Co., the pelletizer nicknamed the flying saucer has been developed. This saucer is somewhat like the one shown at the right of Fig. 3, except it has shelled surfaces so that balls of various diameter may be obtained without recycling the fines; centrifugal force throws the large balls to the outer periphery and over the lip on the conveyor feeding the sintering machine.

At this time the status of the low-grade hematitic ores other than the specular variety is very uncertain. Experimental roasting in a reducing atmosphere to produce magnetic particles is being done at Jones & Laughlin's research laboratory at Negaunee, Mich., and in a pilot plant operated by Republic Steel Corp. and National Lead Co. in the Birmingham, Ala., district. Erie Mining Co. has developed a shaft type of roasting furnace for treating such ores, and another furnace of this general design has been in successful operation for the past three years at the

plant of Manganese Chemical Co. at Riverton, Minn. The synthetic magnetite coming from such treatment is more strongly magnetic than natural, can be separated from the gangue of the ore by magnetic separators, and is much more difficult to demagnetize. Due to the enormous reserves of low-grade hematite ores, the solution of this beneficiation problem may well become the most important research problem facing the steel industry in the next 20 years.

Use on Blast Furnace Burden

One of the great uncertainties of the present situation relates to the performance of the high-grade concentrate pellets in the blast furnace. Although much more than a million tons has been smelted into pig iron at various steel plants, some inconclusive results have been reported. The present author can find no one in the steel industry who will venture a definite opinion as to coke saving at the blast furnace, increased output with a 62% iron ore instead of the present 50%, and decreased smelting costs from lower flux in the burden and lower overhead. Since most of these tests were of short duration and the pellets handled were themselves of an experimental nature, this situation is to be expected. It will take some months — maybe a year — of full-scale operations at the blast furnaces before any accurate evaluation may be made.

The whole economic status of taconite concentrates is thus shrouded in some mystery. Costs are greater than direct-shipping ores because three tons of rock must be mined instead of one, a huge capital charge will apply for the amortization of the processing plants, plus the extra operating expense of concentrating and agglomerating. On the credit side, the high-grade pellets will be free from *ad valorem* taxes levied by the state governments on unmined ore, a much lower royalty fee (at least for the present), reduced shipping charges per ton of iron handled, and a credit for the expected blast furnace economy in smelting a tailor-made, uniform high-grade concentrate.

In spite of these uncertainties, the steel industry simply must solve the problem of using the low-grade hematitic ores of the iron ranges. Beneficiation of magnetic iron ores on a large scale has finally been proven to be possible. It should grow into one of the largest industries in the country. More than \$600,000,000 has already been spent for research and new plants, and many times this amount will have to be added in the next few years to attain the required annual output of 35,000,000 tons of concentrates. ☐

Materials in the Automobile of the Future

By A. L. BOEGEHOOLD*

The future family car will be no smaller than present models; it will weigh less because of generous use of light metals. The spark ignition gasoline engine will persist, but will be more efficient and lighter, even if more powerful. (T 21)

THIS SUBJECT should certainly be of great interest to a metallurgist — and to everybody else for that matter — for, as C. F. Kettering says, "We should all be intensely interested in the future because that's where we are going to live for the rest of our lives!"

Before we talk about future materials, we must have some idea of what the future automobile will be, and any prediction must depend on reasonable assumptions. One assumption is that the causes that have operated to produce present day effects will continue to operate along similar lines, and produce effects in the future from present-day causes. Let us list some of these causes that have been operating in the past.

1. Engineers by nature are impelled to get greater efficiency in the job of transporting personnel and cargo.

2. Conservation of both fuel and metal resources is a strong urge, and is responsible for part of the desire for (a) greater efficiency, (b) elimination of strategic materials, (c) utilization of materials in greater supply, and (d) use of fuel in a manner consistent with conservation.

3. These objectives must be attained at a cost that will create an increasing sales volume and standard of living.

Now let us consider each of these items in some detail.

Efficiency includes first, the mechanical and thermal efficiency of the power plant; second,

the mechanical efficiency of each mechanism in the vehicle and third, the over-all efficiency in terms of resources consumed. This boils down to:

First, a power plant that is most efficient to operate and build and that needs the smallest quantity of strategic and scarce materials.

Second, a vehicle of lowest over-all weight compatible with cost and use of plentiful materials. Low weight must not sacrifice present-day interior roominess. In other words, we are not heading toward a small car.

The above two paragraphs indicate how all three of the causes listed are intertwined — efficiency, conservation and sales volume. So it will not be surprising if I next turn to the last mentioned.

Production — Consider the statistics assembled in Table I on population, car usage, and fuel consumption. Even though the fuel bill for 1955 has been cut by progressive economies through increased compression ratios and higher octane gasolines, the total fuel consumed in 1960 will be almost double due to increased number of cars and increased mileage per car. An 83% increase in gasoline production in the next 15

*Manager of Research Staff Activities, General Motors Corp., Detroit; Past President of *SOCIETY OF METALLURGISTS*. This paper is a shortened version of a talk before the Cleveland District, A.S.T.M., April 12, 1956. He wishes to acknowledge the help of many of his associates at G.M. Research Center, Detroit.

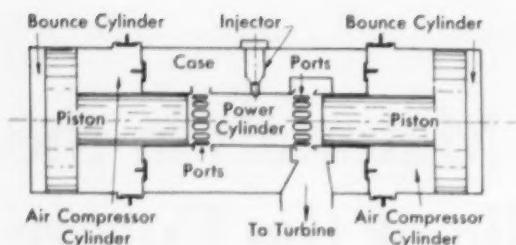


Fig. 1 - Idealized Cross Section of Free-Piston Engine in Starting Position. All valves closed

years will be very difficult to guarantee. To avoid trouble, another way to reduce fuel consumption, besides more efficient engines, must be found. If each car weighed only half as much, the fuel needed to move it along the road would be considerably decreased. This means that lighter materials of construction must be used, and power plants which have the lowest weight per horsepower developed or selected. This results in using less metal, more of the plentiful metals, and less fuel.

The superhighway program can be counted



coming power plant) compares well with the present-day piston engine in weight, can be put in less space, and can use low-grade fuel, but we need much information on how to get along with less scarce alloy such as nickel in the turbine blades.

One way to eliminate much of the need for nickel or cobalt in the turbine blades would be to keep them at a low enough temperature. This has been done both abroad and in this country by liquid cooling; this, however, requires a condenser and radiator to cool the liquid used for blade cooling, and this added complication would sacrifice the weight advantage in favor of the gas turbine. (Another way is to feed cooler gas to the turbine, and that will be described later under the topic of "free-piston engine".) A point that has yet to be cleared up is whether the gas coupling between the gasifier and the power turbine will provide the acceleration now demanded in passenger cars. Even though its

Table I - Population, Automobile, and Fuel Statistics, 1930 to 1980

	1930	1940	1955	1980
Number of automobiles	23,000,000	27,000,000	52,000,000	88,000,000
Population of the U.S.	123,000,000	132,000,000	166,000,000	220,000,000
Persons in U.S. per auto	5.3	4.8	3.2	2.5
Average annual mileage	7,200	9,200	9,600	12,000
Miles per year per person	1,300	1,900	3,000	4,800
Average horsepower	75	125	180	250
Miles per gallon	15	18	20	30
Gallons of fuel; millions	14,000	21,000	46,000	84,000

on to force automobile construction in the direction of lower weight and better fuel economy. Highways will very likely be financed by a tax on gasoline. As gasoline cost increases, the automobile owner will turn to less thirsty cars. This situation in Europe has produced the pint-sized car, which, with generous use of aluminum and magnesium, may weigh about 1600 lb. Although it is unlikely that we will sacrifice roominess and comfort to anything like this extent, we will see better fuel economy per ton-mile of car operation resulting from lighter cars.

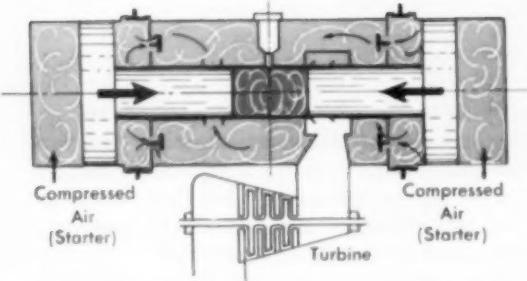
Power Plants

How do various power plants now available compare in this respect? Table II, p. 106, gives some information, and it would seem that the gas turbine (considered by many to be the

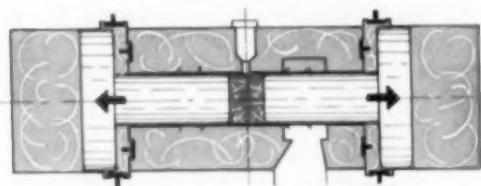
fuel appetite is on the high side and the exhaust gases must be adequately disposed of, the gas turbine will certainly find uses in certain areas such as sport cars and possibly cargo carriers.

Diesels will continue in busses and trucks, boats, and a variety of steady power units, because of the low consumption of cheap fuel. Their weight is necessary to achieve durability while operating a great percentage of time at nearly full power output. A turbo-blower increases both power output and fuel efficiency.

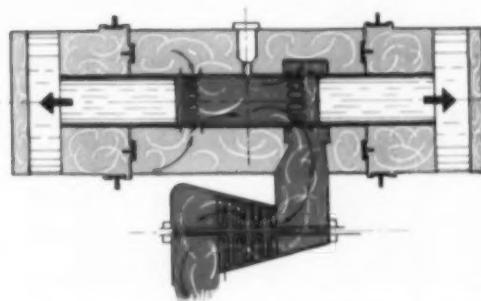
Furthermore, numerous aluminum parts will substantially reduce weight per horsepower and decrease unit size. An aluminum diesel would weigh about 7 lb. per hp. Even this would not be suitable for passenger cars. We can design a diesel engine of lighter construction, but do not anticipate a development in this direction.



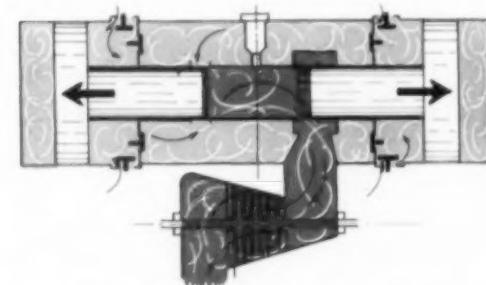
Compressed Air to Bounce Cylinders, to Start. Pistons move inward, closing ports, compressing air in power cylinder, and pumping air into case



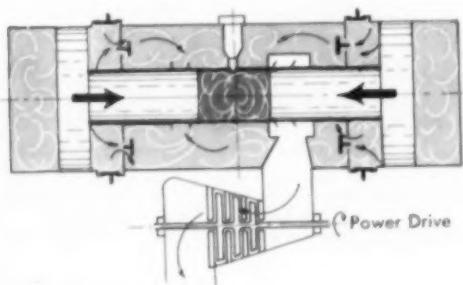
Fuel Injected Into Power Cylinder at End of Stroke



Power Stroke. Air in bounce cylinders is compressed. Intake valves into air compressor open



End of Stroke Opens Ports. Hot gas flows into turbine, and power cylinder is scavenged by compressed air from case



New Cycle Started by Air Pressure in Bounce Cylinder

Free-Piston Engine

The free-piston engine may be a strong competitor to the spark ignition piston engine for passenger vehicles 25 years hence because it can operate on almost any kind of liquid fuel, it is economical to build, and its fuel economy is nearly as good as the diesel's. It is not a new device; over 1200 air compressor units are now in operation; these are quite heavy and are usually rated at about 1000 hp. However, the fact that an engine may be able to burn a lower grade fuel will probably not be an over-riding factor. We have seen how the cost advantage at one time enjoyed by kerosene over gasoline has all but disappeared.

Figure 1* shows the engine and Fig. 2* the operating sequence needed to convert gas horsepower from it into shaft horsepower by way of a gas turbine. There are two pistons opposing each other in a single cylinder. Each piston is constructed with a smaller diameter for the power end and a large diameter for the air compressor end. In Fig. 1 the pistons are shown at the extreme outward point of travel. The space behind the large-diameter pistons contains air that is compressed by the outward motion of the pistons and bounces them back together again. When the pistons have reached the extreme inward position, an injector forces fuel into the highly compressed air, which burns explosively and blows the pistons apart again. The cycle is diagrammed in five steps in Fig. 2*.

During the inward stroke, the large pistons compress the air in the spaces labeled "Air Compressor Cylinders" and this is forced into the casing surrounding the power cylinder. When the outward motion of the two pistons uncovers the ports, the compressed air in the casing rushes through the intake ports at the left and scavenges the burned gasses from the power cylinder, pushing these through the exhaust ports and passageway at the right end into the turbine.

This turbine operates at relatively low temperatures. Whereas the conventional gas turbine uses gas at 1600 to 1700° F., the turbine driven by gas from the free-piston engine operates at 850 to 900° F. The material for turbine blades therefore does not pose a problem of scarce refractory alloys. The advantage of simplicity of the free piston engine, however, may be lost by the complexity and expense of the turbine

*From "The GM 4-4 Hyprex Engine", by A. F. Underwood, General Motors Research Staff, presented at Society of Automotive Engineers' summer meeting, June 3, 1956.

needed to produce shaft horsepower. For good efficiency, it must have four or five banks of rotating blades, each with a bank of stationary deflecting blades. This adds greatly to the over-all cost of building the whole free piston-turbine power package. A radial inflow turbine may be the solution here.

The principal advantage remaining in favor of this engine is that it burns low-grade fuels, such as kerosene or mixtures of Bunker C and kerosene. (Bunker C alone must be treated.) It would appear, therefore, that if free-piston engines ever become the universally used power plant for passenger cars, the output of the petroleum industry would undergo a radical change. In the field of cargo-carrying vehicles, where durability and fuel consumption are important, the free-piston engine will meet competition from the turbo-blown diesel, the regenerative gas turbine, and the high-compression gasoline piston engine made more rugged to stand steady, high-output operation.

Piston Engine (High Compression)

How will the gasoline piston engine fare? In the foreseeable future, the petroleum industry will have gasoline of high enough octane rating at the fuel pumps to permit compression ratios as high as 12 to 1 or 13 to 1. This can be anticipated from the rate of increase since 1947, when C. F. Kettering demonstrated that a car with 12 to 1 compression ratio saved at least 30% of the fuel used in the then current cars with compression ratios of 6 or 7 to 1.

While compression ratios of 13 to 1 will require gasoline of higher octane rating, past performance of the petroleum industry indicates that we can expect to have the desired fuel at that time. Passenger cars will then be operating with a fuel economy comparable to that of diesel engines and free-piston engines. The fuel, however, will be quite different; it is not now available at filling stations, but will have an octane rating of 110 to 120 on the present scale.

As a result of improved fuel economy, lower unit weight and lower unit size, graphically shown in Fig. 3, the gasoline piston engine will be in a strong position to retain its place as the power plant for the future automobile. If we consider that the most desirable engines are those having the shortest bar height in the three categories shown, then it is obvious that gasoline engines are in the most favorable position, especially the engines built with a large proportion of aluminum. These show better fuel economy and lower weight and space requirements than any others. Added to that, all of our manufacturing plants are tooled for production of this type of engine; introduction of a radically different one would involve stupendous costs. There is no doubt, however, that the money would be spent just as soon as another engine shows a clear advantage.

Trend — The trend for the next 15 years, then, would appear to be toward higher compression ratios and the use of more aluminum and magnesium. We can also expect ventures involving gas turbines or free-piston engines, probably at

Table II — Comparison of Engine Types

ENGINE	FUEL CONSUMPTION*		WEIGHT†	SIZE‡	FUEL
	AT MAX. POWER	AT BEST ECONOMY			
Spark ignition piston engines					
Cast iron, 9 to 1 compression ratio	0.48	0.41	3.6	9.1	95 octane
Aluminum, 12 to 1 compression ratio	0.44	0.38	2.2	8.4	110 octane
Aluminum, 8 to 1 compression ratio, turbo-charged, 30% boost	0.49	0.43	2.1	2.1	95 octane
Gas turbines					
Regenerative	0.75	0.75	3.6	3.6	Kerosene
Regenerative (projected)	0.60	0.60	3.0	7.2	Kerosene
Diesel engines					
4-stroke cycle	0.41-0.47	0.38	12.7	26.0	No. 2 diesel
2-stroke cycle	0.42	0.40	12.1	14.8	Kerosene
2-stroke cycle, exhaust-turbo blower	0.42	0.41	11.7	13.6	Kerosene
Free-piston engine	0.48	0.48	3.6	7.0	Kerosene, gasoline or diesel

*Pounds per brake horsepower per hour

†Pounds per brake horsepower

‡Cubic feet per 100 brake horsepower

first in sports cars. We can also consider the possibility of turbo-supercharging in commercial engines and sports cars to get better fuel economy and increased horsepower per unit of size. Passenger cars run at reduced load too much of the time to make turbo-chargers profitable.

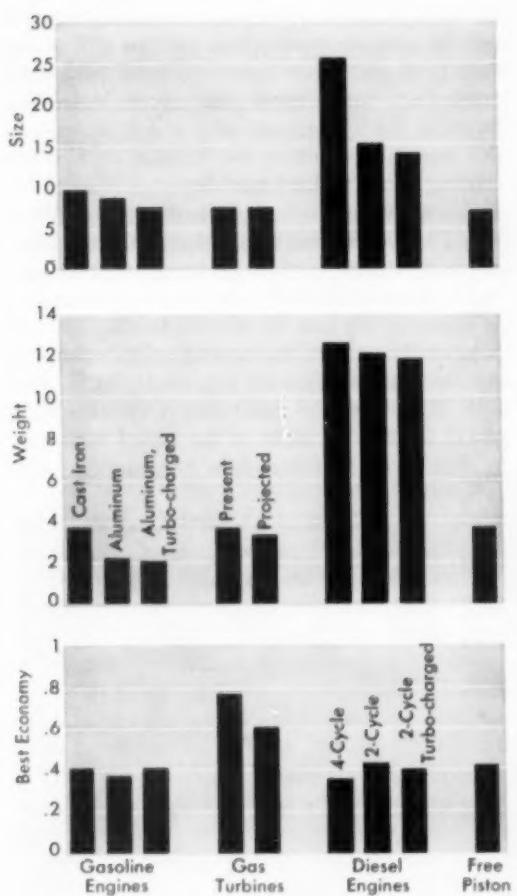


Fig. 3 - Comparison of Engine Types. Vertical ordinates are defined under Table II

Light Metals

In Critical Points for March 1956 the Editor of *Metal Progress* discusses the topic "Light Metals in Our Two-Ton Autos?" This is a matter mentioned in the third paragraph of the present article, namely, conservation of metal resources. Even though we are accustomed to a prodigal use of iron in all our modern tools, machinery, and equipment, a look at the availability of metals on the earth or in the ocean suggests that the colossal annual consumption of metal for

automobiles could be better switched to one that is in greater supply — namely, aluminum or magnesium. The use of iron is especially prodigal in view of the attrition by corrosion which scatters this metal beyond recovery. The automobile industry buys 25% of the total steel production. If a substantial part of this were replaced with light alloys and plastics in some form, the increasing rate of depletion of our iron ores would be given a much-needed brake. The trend toward more light metals has been going on ever since World War II. Before that about the only aluminum in our automobiles was in the pistons, and in some makes these were cast iron. All have now gone to aluminum pistons.

Some form of die-cast aluminum cylinder block will be the basis for reducing engine weight. (This is a logical extension of the change to aluminum that has already taken place in automatic transmissions.) The intake manifold will be aluminum and the exhaust manifold will remain cast iron. The pistons will continue to be aluminum alloy. The low expansion possessed by the present piston alloy may be modified to something compatible with wet aluminum liners, which, of course, will be faced with some wear resistant material comparable to chromium plate, or better.

Automatic transmissions are accountable for another sizable increase in aluminum usage. When the total costs of the finished components are compared, aluminum competes with cast iron or malleable iron. Although the cost per pound of aluminum is high, the cost per piece is sliced to one-third because of its light weight per cubic inch. Cost per cubic inch of iron and aluminum is nearly the same. Machining cost for aluminum is much less, and many parts (which can be made as die castings or permanent mold castings) are closer to finish dimension than iron castings and therefore require less machining.

Another change in the automobile which will lower the weight and save scarce materials will be in the radiator. As copper becomes more expensive and scarcer, the urge to replace it with aluminum will become greater. By 1980, I expect our radiators will be made of aluminum.

The average 1930 car used 4 lb. of aluminum; by 1945 this had only doubled, but by 1955 it had jumped up to 35 lb. Some cars were using 70 to 80 lb. and Cadillac's "Eldorado" contained 192 lb., replacing some 400 lb. of steel. Hence a prediction of 80 lb. per car by 1965 does not seem unrealistic. Another forecast by a leading

engineer in the automobile industry is 100 lb. of aluminum in each of the 8,000,000 cars expected to be built in 1970. This would be equal to the total aluminum production in 1949!

Magnesium's cost per cubic inch is higher than aluminum's, so the present competition from cast iron has prevented much substitution. However, we may expect that oil pans and gear box covers will be die-cast magnesium. In considering eventualities, it is well to keep in mind that each cubic foot of ocean water contains 1 oz. of recoverable magnesium. This doesn't sound like much, but the magnesium in 1 cu. mi. of ocean water would provide 175 lb. of magnesium for every one of the 52,000,000 autos now in the U.S.! Certainly the supply of this metal is truly inexhaustible.

If I do not make some reference to the possible use of titanium in the future automobile, someone is sure to ask about it. No mention has been made because we do not see a legitimate use for it even if the price were low enough to compete. The structure of the automobile is such that weight can be more easily saved with aluminum and magnesium than with titanium. One possible exception would be for gas turbine components operating between 500 and 1000° F., where aluminum or magnesium alloys would be inadequate.

Parts for Engines and Drives

In this brief review, mere mention can be made of many items, each warranting considerable discussion. Valves, for example. Valves will continue to be of heat resisting alloys, universally aluminized, both intake and exhaust. "Aldip" coating more than doubles the life of the valves.*

Piston pins and connecting rods will probably see no change.

Bearings will continue to be steel-backed inserts made by powder metallurgy similar to "Durex 100" or "Moraine 400". The first consists of a copper-nickel porous sintered matrix bonded to a steel back and overlaid and permeated with a lead-base babbitt. The second consists of an aluminum-base silicon-cadmium alloy bonded to a steel back and a thin overlay of lead-base babbitt.

The crankshaft will be made by the process that will result in the lowest cost without sacrificing any engineering requirement. The two

*See "Engine Valves Improved by Aldip Coating", by R. F. Thomson, D. K. Hanink, E. B. Etchells, and K. B. Valentine; S. A. E. Meeting, March 1, 1955.

principal contenders seem to be automatic forging of steel and shell-molded cast pearlitic malleable iron, or shell-molded ductile iron. The large investment in automatic forging equipment now existing in some plants constitutes a major obstacle in the path of change to cast crankshafts. My forecast, however, is that the savings yet to be made in shell molding will make the cost so much in favor of the cast crankshaft that it will be ultimately accepted. (About 25% of the cars produced have been equipped with cast crankshafts for a good many years.) Another factor is the appearance of new alloys, such as the one in production for Pontiac crankshafts starting with the 1955 models.

Shortages in alloying elements during World War II gave impetus to a change in the composition of the steels used in gears, shafts, and other highly stressed members. Our new understanding of hardenability and its relation to alloy content pointed the way to the correct substitutions for the steels relatively high in nickel. S.A.E. 4615 with 1.3% nickel and 8620 and 8640 with 0.65% nickel account for most of the nickel now used in alloy steels in automobile construction today (excluding valve steels).

Nickel is still in short supply, and is quite likely to remain so. Consequently I believe that the future car will use no nickel in the steels for shafts and gears. Great success has already been had with a steel containing 0.50% molybdenum and 0.50% manganese as a substitute for S.A.E. 4615. By adjusting the molybdenum in this composition downward to obtain hardenability in the range of S.A.E. 8620 and 8640, even these could also be dispensed with.

So much for the conventional power plant. What of the suggested new ones - the gas turbine and the free-piston engine.

Gas turbines so far built have used much alloy to avoid any possibility of failure. One 200-hp. gas turbine weighing 700 lb. had 76 lb. of nickel in it. It is obvious that any extended use of such a power plant must involve lower alloy materials. It is reasonable to assume from a study of each part that the same turbine could be made with materials that would perform satisfactorily with a total of 7.5 lb. of nickel and ultimately with as little as 4.75 lb. per engine. Heat resistance in sufficient degree will be achieved in most parts with chromium steels or by aluminizing plain carbon steels. The next 25 years will also see the invention of new alloys for those turbine parts which need to operate at 1300 to 1700° F.

The free-piston engine can be built with metals containing no nickel. The structure of the air chamber and compressor housing could be aluminum alloy for weight reduction; the pistons could be partly of cast iron, and partly of aluminum, to obtain the proper weight for speed control. The cylinder sleeves are steel, heat treated to high physical properties. The compressed air chambers and passages are formed of low-carbon steel. The turbine would have rotor and stator blades of Silcrome No. 1 containing only chromium and silicon, and the case would be pearlitic malleable iron.

Conclusion

Following the example frequently set by the stock market analyst and by some war correspondents, I have now predicted a sufficient range of possibilities for the future so that, when the time comes, I can say that the events were predicted 25 years before. All we have to do now is to get on the job to find out how close to the forecast the future will be.

All I have been saying thus far can be boiled down to a few sentences:

1. Engine and car weights are going down.
2. Engine efficiency will increase.
3. We will use light alloys generously to supplement increased efficiency as a means of conserving fuel.
4. Otherwise, materials will be much the same as now but with less nickel and with more pearlitic malleable iron.
5. The power plant used in the future will have low weight and low volume per horsepower, and will have good fuel economy.

The race between the present type of engine, the gas turbine, and the free-piston engine will be exciting. Size, weight and performance of the gasoline piston engine, which must be exceeded by the gas turbine or the free-piston engine if they are to displace it, are targets that will not stand still. However, improvements we can see in the immediate future indicate that piston engines will drive our automobiles for many years to come. 

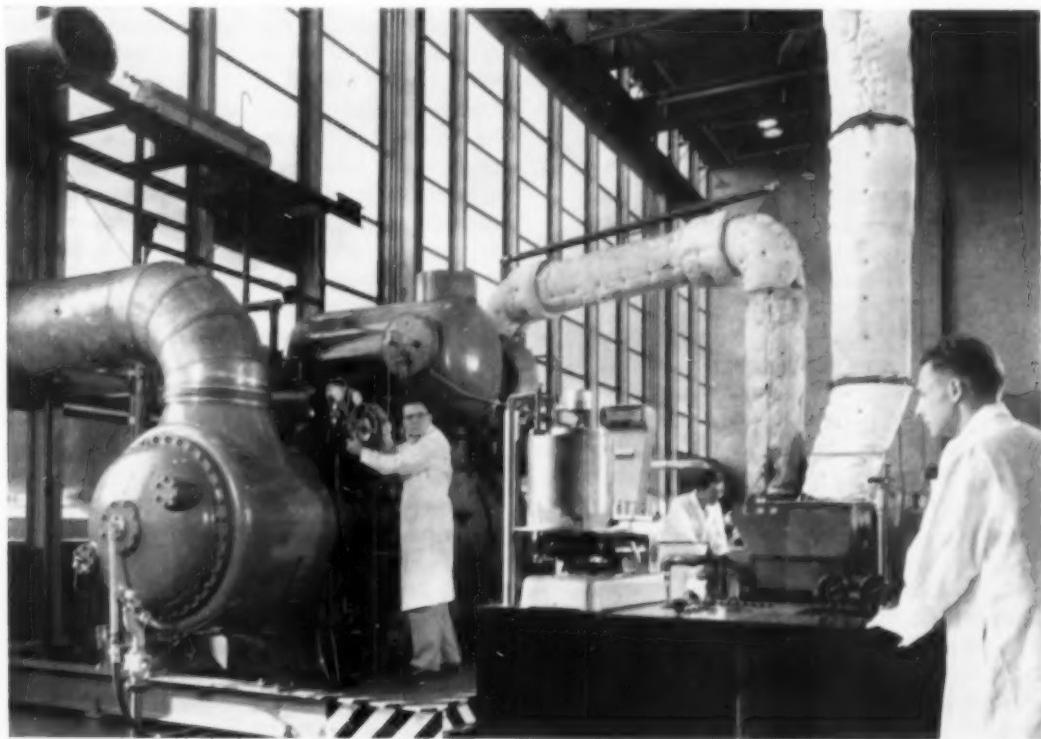


Fig. 4 - Many Free-Piston Engines Are in Use as Air Compressors, but Here We See a Free-Piston Gasifier Under Test - Similar to Six Units General Motors Is Building for the U.S. Maritime Administration for Transatlantic Service

Forming Sheet Metal Components for Aircraft

By JOHN F. TYRRELL*

Designs of aircraft change so rapidly that few sheet metal parts are ever produced in appreciable volume and some unique techniques have been developed to minimize retooling cost. (G general, SG-j)

FORMING DEPARTMENTS in the aircraft industry bear a family resemblance to those in the automotive and other mass-production industries, but their operation involves problems rarely encountered elsewhere. Only during wars are aircraft designs frozen so there can be continuous production of identical components. In peacetime, retooling rather than production is almost continuous, not only because of new planes but also because of modifications in design of "production" models.

The kind of tooling selected for fabrication of sheet metal parts is determined from the best estimate of the number of the parts to be produced, the dimensional tolerances and the kind of material. Seldom are more than a thousand or even a few hundred units produced; a regular "production" run may be ten to twenty components and occasionally only one or two are required. Prior to World War II, the one and two-unit orders were the rule rather than the exception and parts were often formed by hand with a hammer over a bag of sand or a wooden form block.

Hand forming requires the minimum investment for tools and often would be the cheapest method of forming a small number of parts if dimensional tolerances could be met. Unfortunately, aircraft designers now insist on a degree of accuracy in each component which was unheard of in prewar planes and which cannot be

*Associate Editor, *Metal Progress*, Cleveland.

obtained consistently by even the most experienced craftsmen with hand tools. Recently, forming by peening has been revived but instead of a hammer, shot-blasting equipment is used. With proper control of the shot, pressure and nozzle motion, simple shallow contours can be formed quite accurately at low cost on fairly heavy structural parts.

Most sheet metal parts, however, must be formed on dies because of the shape and accuracy required. The conventional method is to make a punch and a die from a material which will wear long enough to produce the number of parts required. Amortization of such dies would be extremely expensive in aircraft production because of the comparatively few parts made, so a number of ingenious methods have been developed to eliminate the need for either the punch or die.

In the Guerin process, only a punch is used and a confined rubber pad is used as the female die. The sheet to be shaped is placed on the punch and a thick rubber pad forced down on the sheet. The sides of the pad are confined in a steel box and the punch is placed on a steel plate which enters the rubber box. The hydrostatic pressure developed in the confined rubber forces the sheet to conform to the shape of the punch.

The process was developed at Douglas Aircraft Co. early in World War II and was quickly adopted by other aircraft companies for form-

ing shallow flanged parts or for making the shallow depressions used to increase rigidity of flat panels. The depth of drawing is usually limited by the thickness of the rubber pad but can often be increased locally by placing small pieces of rubber over the blank on areas which require maximum deformation.

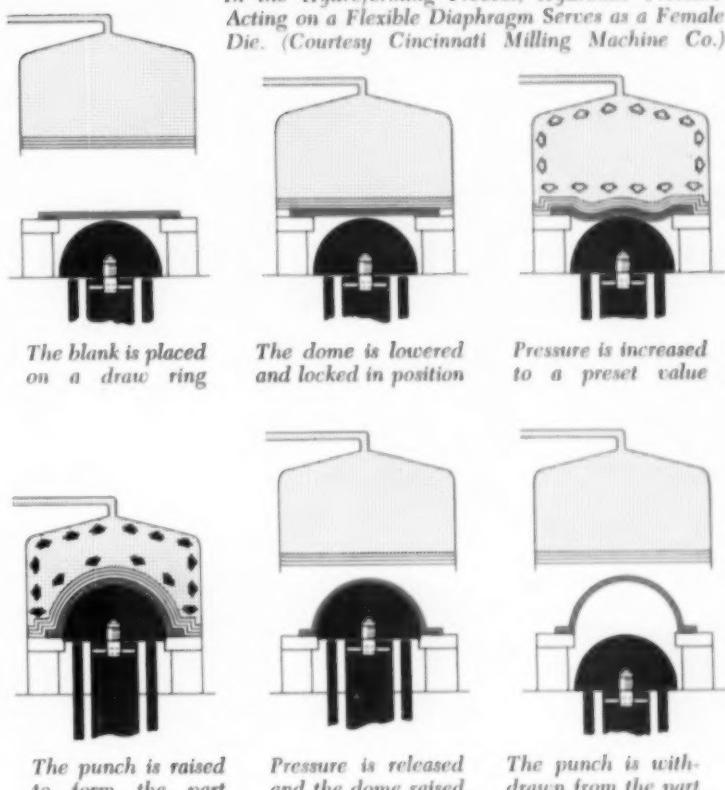
This limitation on the depth of draw is not the only disadvantage of the Guerin process; the initial contact of the rubber and blank can move the blank out of position, so it is necessary to use positioning pins in the punch with holes in the blank to correspond. Although such holes are often specified in aircraft components for weight reduction, they definitely reduce the number and variety of parts which can be formed by this method.

These limitations have been partially overcome by the newer Verson-Wheelon press in which the rubber pad is replaced by a hydraulic cell covered by a thin rubber diaphragm. The steel plate carrying the punch and blank remains fixed. As the hydraulic pressure is increased, the flexible diaphragm covers the blank and forces it down and around the punch. The forming pressure is much greater than that obtainable in the Guerin process and is uniform on all sides of the punch and in all directions. Deeper draws and better side detail are possible and yet the equipment is much simpler and cheaper than conventional hydraulic or mechanical presses of the same capacity.

When either process is used to form small parts on a large press, a number of punches can be used simultaneously to cover the full area of the steel plate. To reduce idle time of the press, four or six movable plates are used so that while one group of parts is being formed, others are being loaded or unloaded.

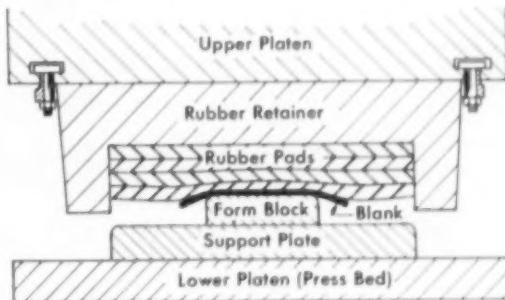
Hydroforming is another method of forming drawn parts which uses hydraulic pressure acting

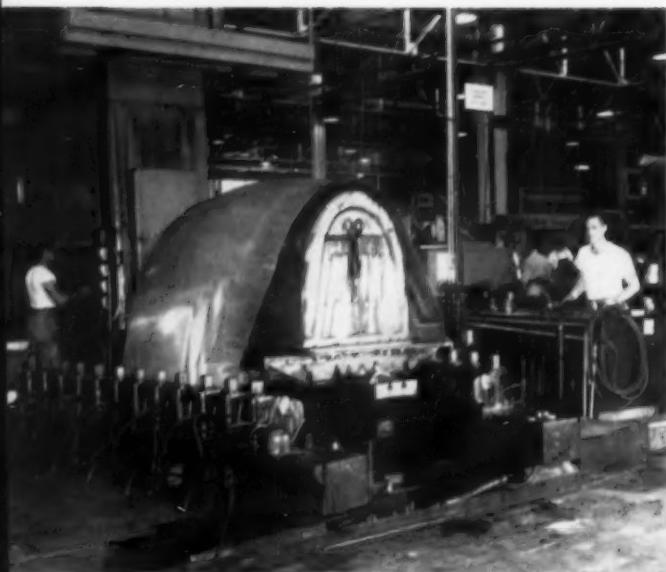
In the Hydroforming Process, Hydraulic Pressure Acting on a Flexible Diaphragm Serves as a Female Die. (Courtesy Cincinnati Milling Machine Co.)



on a flexible diaphragm as the female die. The punch is in the center of the press with a draw ring mounted on the support slightly above the top of the punch. The blank is placed on the ring and the hydraulic dome is lowered over it and locked in position. The pressure is increased to a predetermined value and then the punch is raised to force the blank into the high-pressure fluid. Forming pressures as high as 15,000 psi. can be developed and are uniform over the entire

Rubber Pads Are Used Instead of a Female Die in Forming Shallow Aircraft Parts by the Guerin Process





*Stretch Forming an Aircraft Component
by Forcing a Form Block Into a Sheet
Whose Edges Are Held in Fixed, Parallel
Jaws. (Courtesy Ryan Aeronautical Co.)*

punch so that deep draws can be made with very fine side detail.

The punches used in all of these forming methods are usually made from "Kirksite", a zinc-base casting alloy. If only a few parts are required and the pressure is not too high, the punches can be made from plastic, impregnated fiber or hardwood. For long runs or high-pressure forming, brass, aluminum, cast iron or steel is used.

Stretch forming is used to produce large parts of comparatively simple contours such as panels, cowlings and fairings. The first of these stretch presses were simple rams which were raised between fixed parallel jaws that held the sheet or blank taut. A punch, or form block, was mounted on the ram. As the punch rose the sheet was wrapped around it and assumed its contour. A modified unit has movable jaws so that the blank can be prestretched beyond its yield point before the punch is raised so that the amount of springback can be reduced. Punches are made of wood or plastic so that considerable savings in tooling for short runs are realized.

Several improved versions of this process have been developed and its utility has broadened to include forming of bars and extrusions in addition to sheet. The jaws are free to move both

horizontally and vertically so they can be lowered as the ram is raised between them.

In another kind of press, the punch is horizontal and may be either stationary or movable. Either one or both of the jaws is rotated to stretch and wrap the part around the die. Some of this equipment can form sections a full 360° or even make continuous spirals. A radial draw former produced by Cyril Bath Co. is one of the latter but in addition it has a third movable arm which presses a "traversing shoe" against the outer edge of the part. The shoe acts like a female die and permits deeper and much more accurate contours to be formed. The dies used in stretch-wrap forming are usually made of steel or cast iron to withstand the high forming pressure developed.

The light metals, aluminum and magnesium, are the most used for aircraft parts and although they are formed by the same processes, there are some differences in the techniques employed. Magnesium alloys are usually formed warm because their formability is low at room temperature and increases with temperature to an optimum at about 600° F. When rubber is used in the forming operation, the maximum metal temperature is held below 450° F. and special heat resistant rubber must be used. The blank and die are usually preheated together in an oven and transferred to the press for forming. Zinc-base dies may be used satisfactorily but cast aluminum or magnesium alloy dies are generally recommended.

The common high-strength aluminum alloys whose strength is developed by precipitation hardening represent the other extreme in temperature control for forming. They are usually drawn in the solution treated condition and then age hardened after forming. Most of the alloys age harden slightly at room temperature so that they must be formed as soon after solution treatment as possible. Aging may be retarded by keeping the sheet at a low temperature, about -20° F., in a refrigerated container until the drawing operation can be performed.

The cost of both the tooling and the labor involved in forming aircraft parts has increased with the increased use of the newer, less ductile materials such as titanium-base and high-temperature alloys. Much development work is currently being sponsored by the aircraft industry to halt this trend, but progress in aircraft design is so rapid that when it is learned how to fabricate the alloys now being used, there will inevitably be newer, tougher materials in production to contend with.

Recent Developments in the Art of Precision Casting

By NICHOLAS J. GRANT*

Time-tested processes using disposable patterns (wax, plastic or mercury) must compete with others using a thin-walled mold in which the casting solidifies quickly to a fine grain. (E 15)

As RECENTLY as 1940 the now rapidly maturing precision investment casting industry was just emerging from the jewelry, dental and surgical trades. The sudden demand in World War II for vast quantities of supercharger buckets cast of a nonmachinable stellite alloy for the rapidly expanding aircraft program set in motion the broad commercialization of investment castings in ever increasing quantities.

The growth of this industry and a number of the features responsible for the growth are of particular interest. Gross sales in 1953 were about \$95 million; this value rose to about \$106 million

in 1954. The latest figures for 1955 indicate about \$135 million. Based on the volume of work done thus far in 1956, it appears that an estimated value of \$150 to 175 million may be expected—an increase of 75% in only four years!

Thus far this growth is based almost entirely on two more or less conventional investment processes—namely, the plaster-bonded silica investments for nonferrous castings, and the several high-temperature bonded silica investments for ferrous and high-temperature alloys. The second process utilizes as the bonding agent tetra-ethyl silicate, or "Nalcoag", or a phosphate. To date, the great bulk of all the precision casting has been with disposable patterns, usually made of wax or plastic but also of frozen mercury. The word "conventional", used above, does not signify in any sense that new techniques have not been tried or that there have not been significant developments and improvements.

Perhaps the best single measure of the maturity of the industry has been the formation of the Investment Casting Institute, a trade association now composed of 31 regular members (metal casting groups) and 17 affiliate members (suppliers and equipment producers). Its activity in the formulation of appropriate and acceptable design and inspection standards will be commented upon later in this article.

Before taking a look at several new precision casting techniques, notable developments within the industry as above delimited are worthy of comment.

Size of Castings—The most frequent size of casting from lost wax or plastic molds has been and still remains from 1 to about 4 oz.—usually

*Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.



Fig. 1—Gimbal Weighing 0.52 Lb. Cast of A.I.S.I. 8630 Steel. Wall thickness 0.030 to 0.045 in. Previously sand cast and completely machined. (Courtesy Howard Foundry Co.)

Fig. 2 - Cross Section of Impeller for Boiler Feed Pump. Type 410 stainless; weighs 23 lb. (Courtesy Misco Precision Casting Co.)

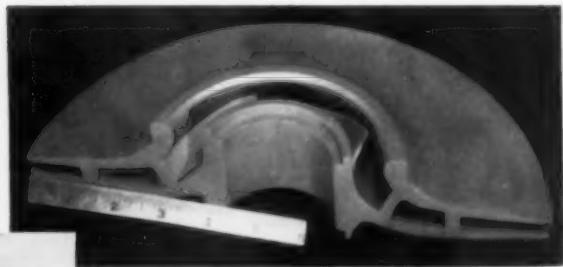


Fig. 3 - 4-Lb. Mounting Bracket for Ram-Jet Engine of Cr-Mo-V Steel, Heat Treated to 180,000 Psi. Ultimate Strength. X-ray inspected for soundness. (Courtesy Engineered Precision Casting Co.)

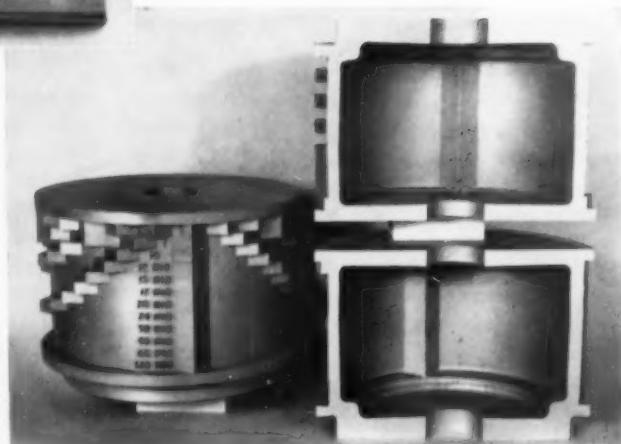


Fig. 4 - Time-Cycle Controller, Exterior and Cross Section. Hollow casting of beryllium copper replaces stack of aluminum alloy disks. (Courtesy Precision Metalsmiths, Inc.)

as a complex but compact body. A typical example of such a small complex part is shown in Fig. 1, a gimbal of alloy steel (A.I.S.I. 8630) weighing 0.5 lb. This is small enough so a fairly large number of pieces can be assembled in one flask, thus resulting in low unit price.

However, the past five years have seen a real departure from this situation in that more and more of the dollar volume is going into castings weighing from 1 to 10 lb. or more, with the larger fraction at 1 to 5 lb. per finished casting. Dimensional accuracy and high surface finish have been maintained at almost the same level as for smaller castings. In fact, as the size of castings increased, the inspection and quality control requirements increased; the principal demand of small precision castings is for high dimensional accuracy, and this has been superseded by strength and ductility requirements in the larger parts.

Figures 2 to 4 show representative castings of the larger types that are being produced at the present time.

Figure 2 shows a cross-sectioned boiler feed pump impeller made of Type 410 stainless steel and weighing 23 lb. The surface finish, as cast, was so good it resulted in 7% greater pump efficiency when compared to the sand-cast product which had been subsequently tooled.

Figure 3 shows a much simpler casting — a mounting bracket for a ram-jet engine made of Timken 17-22 AS alloy (1.2 Cr, 0.5 Mo, 0.25 V), weighing about 4 lb. and heat treated to 180,000 psi. minimum tensile strength. This part had previously been made as a weldment from pieces of machined bar stock. Casting gave the advantages of truer dimensions, X-ray soundness and lower price.

Figure 4 shows a piece in perspective and cross section which almost falls into the category of a "man bites dog" story. It is of beryllium copper and *lighter* than the aluminum piece it replaces! It is a drum whose rotation brings the cams, cast in its surface, in contact with fingers set at required levels so natural gas can be injected into oil wells at required frequency.

(This is a method of pumping oil wells known as the "gas lift".) The drum was originally made from a stack of aluminum disks, bolted together. Cast in beryllium copper as a hollow part, the weight is reduced 40% and machining time cut 75%. Net weight of the casting is 4 lb., 11 oz.

It is obvious that the larger castings are of as complex a shape as the older ones in smaller sizes. It should also be pointed out that the Mercast process has always produced the larger sizes of castings as typified by these three photographs.

One can predict with fair confidence that further growth in the precision investment industry will — to a significant extent — take place via such larger castings, since they constitute a new class of business rather than an expansion of the old field.

These improvements in large castings have been possible primarily through modifications of the conventional investment casting methods. These modifications include a greater use of steel dies, wax injection at higher pressure, and modifications in precoating and investing to produce stronger molds.

Quality, Standards, Specifications — Of particular interest has been the increase in X-ray and surface inspection requirements, due especially to a large quantity of aircraft work.

One of the greatest services of the Investment Casting Institute to its members and customers has been the establishment of standards and specifications. Saddled for many years with wrought alloy specifications, the industry suffered from unrealistic demands placed on its products. Working committees have been established for the following activities, and in most instances firm standards or specifications now exist:

1. Metal specification for precision investment castings.
2. Dimensional tolerances.
3. Physical and nondestructive testing.

These standards will eliminate much confusion and fanciful demands, and will serve as a basis for new processes or for comparison with competitive processes.

In addition, the Institute has undertaken the task of preparing a manual so designers of parts can plan directly for precision castings. Currently many drawings must be modified excessively to convert a part originally designed, for example, for a sand casting or a die casting. Information on dimensional tolerances, section sizes, finish, machining tolerances, and similar essential items will be included.

New Casting Techniques and Processes

For years "precision casting" has been synonymous with "ability to cast alloy compositions which are nonmachinable or poorly machinable or nonforgeable". Furthermore, the cast structure has superior creep resistance and rupture strength compared to analogous forged compositions for high-temperature use. Whereas the iron-base and cobalt-base alloys have been cast without difficulty, the nickel-base alloys such as Inco 700, Waspalloy, M-252, and Udimet 500, have given trouble from their titanium and aluminum content. Even with vacuum melting and casting, forgeability and machinability approach zero with increasing alloy.

On the other hand, recent developments in vacuum melting, vacuum melting and casting, and casting of vacuum-melted alloys in an inert gas atmosphere have extended the precision casting of such alloys to higher alloy content than is permissible for forged products, and this often raises the maximum permissible temperature in operating the part. In fact, vacuum techniques have become standard procedures in many precision casting foundries. Large improvements in properties and soundness — especially freedom from gas pinholes at the surface — have been made by air melting but vacuum casting of aluminum alloys, brasses and bronzes.

Some promise has also been indicated for the casting of titanium in small section sizes. There are, in fact, few alloys which are not being precision cast today, provided the melting point is not much greater than about 3000° F.

Decarburization — A common ailment in the steel foundry — especially when using the hot mold technique in the investment foundry — is the serious decarburization resulting from slow cooling through the temperature range of 2300 to 1300° F. Carbon restoration or recarburization heat treatments are available so this is now no restriction on the casting of steel compositions.

Core Developments — While precision casters have amply demonstrated their ability to cast cored holes of all shapes, particularly as evidenced by intricate wave guide castings and hollow nozzle vanes for jet engines (to mention only two classes of castings), there are frequent instances where the cost of machining and assembling suitable dies becomes prohibitive. This difficulty is being met by water-soluble wax inserts and other intricate coring techniques, which have made large savings in cost and time.

and permit freedom of design hitherto unknown.

Control of Structure — Grain size control in precision castings has now been demonstrated. While grain size control is seldom an item in a specification, a number of foundries now control the temperatures of the flask, pattern and hot metal pouring, and so are able to reproduce macrostructures within reasonable limits.

New Processes

The above developments will in all instances be applied to new as well as the old casting processes. All such improvements automatically ease the advent of any new process. Some of these new schemes which have received attention or have been attempted commercially here or abroad are briefly noted below.

The Investment X Process has been described by J. S. Turnbull in *Proceedings of the Institute of Mechanical Engineers* for 1955, and in *Foundry Trade Journal*, Jan. 13 and 20, 1955. It utilizes a disposable pattern of wax or plastic but avoids the usual investing procedure in producing the mold or flask. Instead, a thin coating of fine precoat silica compositions, bonded with tetra-ethyl silicate, is applied, then stuccoed with a coarser refractory for mechanical strength, and tunnel dried. From five to eight such layers are applied to the pattern's surface, depending on the size of the casting. The wax is removed

Fig. 6 — Pouring Off Excess Slip From Porous Plaster Mold After Shell Has Been Deposited



Fig. 5 — Typical Three-Piece Shaw Process Mold and Resultant Casting. (Courtesy Shaw Process Development Corp.)

by solution in trichlorethylene at room temperature, thus avoiding cracking the relatively thin investment shell that results from the wax expanding before it melts, as in the usual melting-out technique. This shell, $\frac{1}{8}$ to $\frac{1}{4}$ in. thick, is then supported in a mass of granular refractory. Wax and solvent are recovered and re-used.

It is reported that considerably larger castings are possible than can be made by the bulk investment process. While the thin shells are undoubtedly less sensitive to a heating rate on receiving the molten metal, the large coefficient of expansion of the silica will certainly result in some difficulty. The thin shells, if cast unsupported, will radiate heat rapidly from the melt and the castings would have a finer grain, and would be less subject to decarburization. Thus far the writer knows of no applications of this English technique in America, although it appears that its advantages should outweigh the anticipated shortcomings.

The Shaw Process, as described by A. Dunlop in *Metal Industry* for Oct. 30 and Nov. 6, 1953, was also developed in England. It is not a disposable pattern technique, but instead uses a wood, plastic, plaster or metal pattern — usually a positive pattern — to produce a two-piece or more complex mold. A silica investment bonded with ethyl silicate (other refractories may be used) is poured against a match-plate pattern and time given for the silicic acid gel to form. In this condition, the gel endows the refractory with significant flexibility so the mold can be stripped from patterns with negative draft. The refractory mold-section is immediately fired — it ignites readily from the alcohol in the gel.

Craze cracks are produced during firing but are too fine for metal to penetrate. The fired mold sections are assembled, heated to the desired mold temperature and cast. Figure 5 shows a three-piece mold and the cup-shaped casting. Large castings up to 200 lb. are reported. Surfaces are not as finely smooth as by conventional investment casting or by the Investment-X process because a somewhat coarser sand is required for a stronger mold.

While the process has been operated in England and Switzerland for a number of years, it is relatively new in this country. Its advantages include the use of a permanent pattern without necessity of precoating, ability to handle no-draft or slightly undercut shapes, and extension to larger sizes. On the other hand the master pattern is somewhat expensive, the accuracy of the product is impaired by the split mold, molding is slow and the casting's surface is rougher than a precision investment casting.

The Glascast Process* — Like the above Shaw Process, this works from a match-plate pattern of wood, plastic or metal. Against this pattern the workman casts plaster molds which in turn are used to slip-cast shells. This slip is a water suspension of finely ground (-325 mesh) "Glascast" powder, a glass with ultralow expansion, approximately 97% SiO₂ with 2.5% B₂O₃. This slurry is poured into the box-like mold of porous plaster, and after standing 5 to 10 min. the plaster absorbs most of the water from the slurry in contact with it, and the excess is poured off (Fig. 6). The slip-cast shells, about 0.10 to 0.20 in. thick, are fired at about 1900° F. to a relatively strong shell. After assembling a mold of two or more shells, it is heated to the desired casting temperature (1800° F. for gas turbine alloys). Molds can also be cast cold.

Cobalt alloys can be cast in such preheated molds when the metal is up to 3200° F. without



Fig. 7 — Turbine Bucket Pressure Cast of Cobalt-Base Alloy Into Hot "Glascast" Shell, Before Any Trimming or Cleaning

reacting with the molds. The latter have unusually good heat shock resistance and hot strength which permits casting in unsupported shells without danger of cracking. Thin shells mean rapid solidification and fine grain size in the product, also a minimum of decarburization. Vacuum casting would also appear to be practicable because of the small amount of refractory and therefore a low gas content.

Figure 7 shows a typical casting pressure cast, as removed from the mold, before any cleaning has been done. Unusually fine surfaces (40 micro-in. finish or better) have been achieved in great part due to use of finely divided ceramic and to a lack of precoat defects. The disfiguring flash is paper-thin, and is caused by the necessity for wiring the half shells together; cementing them gives so strong a mold that hot tears can occur. This is the source of the main dimensional uncertainty in such parts, which is on the order of ± 0.005 in. per in.

This process is not yet in commercial production, but is currently receiving extensive experimentation and trial runs.

Summary

While these and new processes appear promising for precision metal casting and offer, in particular, opportunity for making still larger castings, the conventional precision investment process continues as the major commercial process. Sufficient improvements in technique have been achieved so it can rapidly grow and expand into the manufacture of larger castings than originally imagined. Certainly, further rapid growth is indicated. Some of the newer processes may well accelerate this trend, especially through production of pieces in the 10 to 200-lb. range.

*See N. J. Grant and R. M. Smith, *American Foundryman*, August 1955, p. 30.

Operating records in a cold metal shop having three 75-ton openhearts and two 75-ton electrics show that the latter can make steel faster and cheaper whenever scrap costs less than pig iron, and the product has equal or better quality. (D 2, D 5, ST)

Electric Versus Openhearth

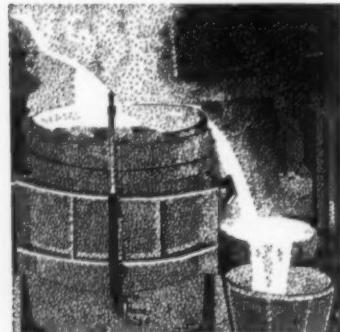
By J. E. WILBANKS*

To understand fully any comparison between the operation of cold metal openhearth and electric furnaces, it is necessary first to understand something of the characteristics of each type of furnace, both from an engineering and from a metallurgical standpoint. While the fundamental chemical reactions involved in melting cold charge and refining to carbon steel are identical in both furnaces, we find two radically different approaches to the mechanical problems.

In a cold metal shop the openhearth furnace has many shortcomings and few virtues. It is subject to many variable conditions which affect its operating characteristics. It is badly handicapped by its inherent charging operation. However, it does utilize cheap liquid or gaseous fuels and it will melt reclaimed or pit scrap and other scrap with considerable nonmetallics.

The refractories in an openhearth furnace ordinarily require a considerable amount of maintenance, and because of its bulk and its operating characteristics, refractory cost per ton of ingot is high. On the other hand, the repairs to an electric furnace roof and lining are accomplished in 10% of the time with only one quarter of the labor force required for repairs to an openhearth.

Heat input to the openhearth furnace is limited by variable flame characteristics and inefficient combustion. Even more serious, the heat absorp-



tion is limited by low temperature differential and relatively large heat losses. At all times the operation of the furnace is subject to human control, and optimum control of operation rarely is attained even when the best instrumentation is installed.

Metallurgically the openhearth is limited by its oxidizing atmosphere which results in high oxygen pickup during melting. Considerable sulphur is also absorbed by the metal as a result of prolonged contact with the flame. These characteristics require large slag volumes and the use of pig iron in the charge, both of which add to the cost of operation.

Production varies throughout the life of each furnace, and drops noticeably toward the end of each campaign. This is in sharp contrast to the performance of an electric furnace which produces steel at a steady rate through the life of each lining.

*Superintendent of Melting, Atlantic Steel Co., Atlanta, Ga. Notes on a talk given before the Southern Metals Conference held in May in Winston-Salem, N. C.

While the electric furnace was developed primarily for the production of expensive alloy steels, modern mechanical improvements and low charging costs have adapted it to the less costly carbon steels. As a result of careful design, most of the undesirable features of the openhearth are completely absent in the modern direct-arc furnace.

This furnace is designed with a minimum area to its volume, and hence with low heat loss by radiation, it can maintain a metallurgically neutral atmosphere, it produces heat without any contamination from sulphur or excess oxygen, and it is mechanically adaptable for rapid charging, easy slag removal, and maintenance of the bottom. Roof changes and major repairs are done quickly with a minimum work force.

The rate of heat input and absorption during the melting period apparently is limited only by the capacity of the furnace transformer, and during the entire operation the heat input is held at peak efficiency by automatic control mechanisms. During the melting period the arc is entirely submerged in cold scrap, but during the refining period heat input is necessarily limited because of furnace refractories which are exposed to direct radiation from the arc.

Since the cold charge is melted, to some extent, from the bottom, the strong boils of the openhearth are absent during the refining period. This results in some difficulty in transferring oxygen from the slag to the metal, particularly in the low-carbon rimming steels. This sometimes results in excessive concentrations of iron oxide in the slag and consequently in higher refractory cost for both furnace and ladle.

Rate of production and furnace availability are both high. Typical months of operation at Atlantic Steel Co. show that an average production of 8.5 tons per hr. is representative of our openhearts, while 16.5 tons per hr. is representative of the electrics. (Both tap 75-ton heats and make the same grades.) Furnace availability approaches 90% in our three-furnace openhearth shop, while the two-furnace electric shop has maintained 95% availability.

The major factors of ingot cost in our cold metal plant are raw materials, fuel and labor. In our particular plant we find that the cost advantages favor the electrics. Under conditions where pig iron and scrap cost about the same there will be very little difference in the cost per ton of steel as made by the two processes.

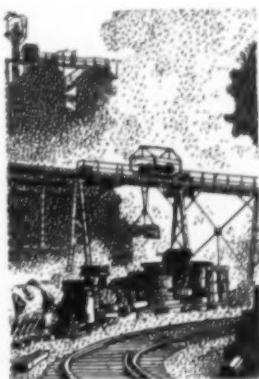
Quality—In general, after four years of experience in making the same grades of steel in both the openhearth and the electric furnace, we have been able to find no real difference in quality that was not traceable to chemical composition or deoxidation practices.

I believe that furnace builders and steelmakers agree in predicting the continued rapid growth of electric steelmaking. On the basis that the projected 60 million tons of new capacity in the next 15 years will raise our total ingot capacity to about 185 million tons, electric ingots will probably rise to about 15% of total ingot capacity, as compared to about 8.5% now. I question whether we will see any more openhearth shops built for cold charging, as would be the case in the nonintegrated plant.

In summation, I would like to pin-point what we believe are the numerous clean-cut advantages in favor of electric furnaces.

1. Cost of the initial installations should be 40% less than for equivalent openhearth capacity.
2. Less space is required; electrics can be built for expanding capacity where available space is limited.
3. Electrics can be operated by either the single-slag or the double-slag process.
4. Flexibility in operation—electrics can be operated around the clock or any part of the time as needed.
5. The high thermal efficiency of the electric arc permits the operator to control the temperature more closely without any danger from sulphur-bearing liquid fuels.
6. An electric furnace can use most types of scrap at a lower preparation cost.
7. An electric furnace plant is one way to combat centralization of the steel industry in the hands of a few large corporations.
8. Only by electric furnaces can the operator obtain a flexible balance in an integrated plant.
9. In making alloy and special steels, the electric has the advantage due to better alloy recovery.
10. Electric furnaces can do everything openhearth furnaces can do and do a better job making quality steel.

In consideration of the fact that, in the last 20 years, electric furnace capacity has increased 925% compared with 61% for openhearth capacity, it is certain that the electrics have a very bright future in the steelmaking industry—and especially in cold metal plants.



Metal Powder Rolling— a New Fabrication Technique

By SAMUEL STORCHHEIM*

Wartime work in Germany on driving bands for artillery shells has been extended in America to 18-8 stainless steel and other powder metal combinations for manufacturing fuel elements for atomic power reactors. (H 14, Fe, SS, Al)

A FASCINATING and relatively new metallurgical fabrication process is the rolling of metal powder into finished strip. While it is still in the state of experimental development in America, its potential is as important as other newcomers, such as extrusion and co-extrusion of metal powders, hot pressing of powders and—to go into other branches of the metals industry—continuous casting and static pressure welding.

Rolling of powder into strip is by no means new. It was first studied in the experimental department of the German electrical firm of Siemens and Halske and actually patented in 1902. A patent was issued in 1938 to the American, Charles Hardy, concerning the rolling of metal powders transported through the rolls on a carrier.

Apparently nothing much was done with the idea until World War II, when the Germans tried it as a means of consolidating iron powder into rotating bands for projectiles. B. M. Pearson reviewed these attempts in *Iron Age*, Feb. 1 and 15, 1951, and one of the leading German investi-

gators, Gerhard Naeser, described his work before the 4th International Mechanical Engineering Congress in Stockholm, Sweden, in June 1952. His data about this will be freely quoted in the present contribution.

Returning home from the Stockholm meeting, Henry H. Hausner interested the Sylvania Electric Products Corp. and the U.S. Atomic Energy Commission in the possibilities, and it was the writer's good fortune to be involved directly in the work under an A.E.C. contract. Since many of the metals used in atomic reactors, as well as the fissionable or fertile metals thorium, uranium and plutonium, are reduced from purified chemical compounds in powder form, the first fabrication step is usually one of consolidation. The plan of rolling such powders—either pure or when mixed with others in desirable alloying proportions—appeared to have considerable advantages over those existing methods requiring heat and associated dangers of contamination by surroundings and containers.

At Sylvania's laboratories at Bayside, N. Y., we did some of the first rolling of hard metal powders, particularly of 18-8 stainless steel, but we also pioneered the rolling of aluminum powders. Considerable information on the formation of 18-8 stainless strip was published by the

*Assistant Chief of Materials Section, Glenn L. Martin Co., Baltimore, Md. The author wishes to record his gratitude for help in preparing this article to Bernard Sprissler and Walter Marz, engineer and engineering laboratory assistant, respectively.

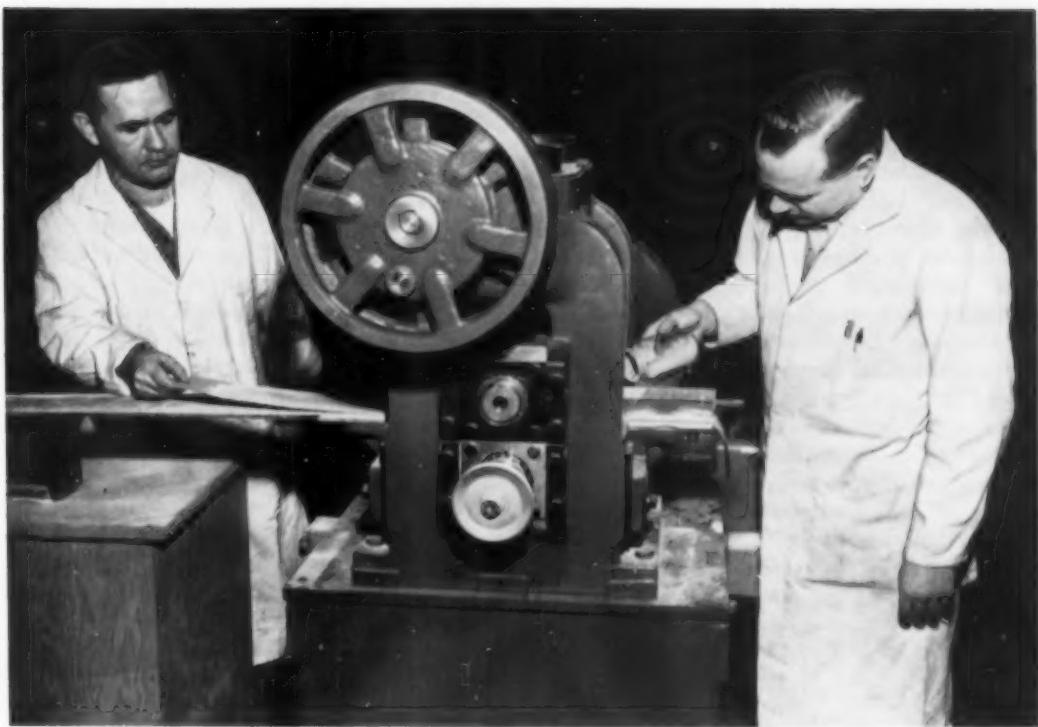


Fig. 1 - Horizontal-Feed Powder Rolling in the Laboratory, Using a Paper Strip for a Carrier

present writer with J. Nylin and B. Sprissler as co-authors in *Sylvania Technologist*, April 1955, and this document is also quoted freely later in the present article. Following these disclosures, the process has been picked up by several other laboratories and plants, including the Whitaker Metals Corp., in North Kansas City, Mo., where reclaimed copper scrap in powder form is rolled into strip. The Glenn L. Martin Co. is studying the process and is applying this new technique to the production of nuclear fuel elements. In addition, rolling of nickel powder is being done in Great Britain as a method of handling fine metal produced during the decomposition of nickel carbonyl.

Aims to Be Achieved

Well, why do we want to roll powders? What are the advantages?

One prime advantage — which applies to all powder metallurgical methods where the part is compacted cold and never heat treated under conditions which cause excessive grain growth — is that unique properties can be obtained with very fine grains. High mechanical strength is frequently associated with such compacts as they

approach theoretical density and a vanishing amount of porosity. Second, it has been observed that such rolled sheets have no crystallographic orientation, that is, the metal grains are randomly oriented. This is potentially applicable to forming uranium sheet for reactor elements, as oriented uranium usually grows to a damaging degree under irradiation. Third, the British have shown that purer nickel sheet can be obtained this way than by conventional techniques. Fourth, powder rolling does not require such large capital investments in equipment; that is, much of the apparatus needed for melting, casting, hot rolling ingots and then cold rolling slabs of metals into thin sheets is done away with. Fifth, a metal strip can be clad on one or both sides by using it as a carrier of the chosen powder through the rolls. Sixth, a larger percentage of any scrap material reclaimed in powder form can be made into strip, rod, and wire more cheaply than by conventional techniques. Finally, there is the advantage found in the rolling of complex core materials for fuel elements, such as aluminum plus uranium dioxide. In cold working compacts made by conventional means down to finish size, it has been found that the uranium oxide will

"stringer" — that is, line up and possibly fracture. This is considered quite detrimental for subsequent use in reactors. However, by rolling powders into finished strip we have observed that the oxide particles do not stringer but remain randomly oriented and uniformly dispersed. (Uranium dioxide and aluminum are of course not the only useful combinations.)

It is, of course, necessary to have some ductility in the metal powders being used; otherwise, no plastic deformation and subsequent interlocking of the particles would occur. Actually, rolling has been used for pulverizing brittle materials.

As noted by Dr. Hausner in his review of the development of powder metallurgy in *Metal Progress* for September 1955, powder metal products are no longer limited in dimensions by die size or press capacity. "Powder rolling is already producing long metallic bands or sheets, either of high density or of controlled porosity, characterized by a randomly oriented fine-grained structure. Copper, brass, iron or stainless steel sheets of any desired length can now be produced at low cost."

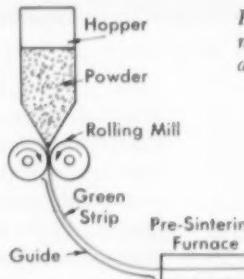
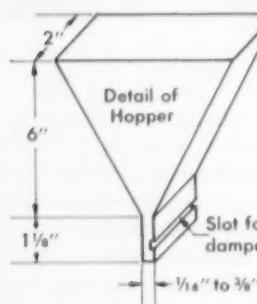


Fig. 2 — Schematic View of Equipment for Producing Strip 2 In. Wide, and Detail of Hopper and Chute

Techniques of Powder Rolling

In the rolling of powder, the rolls may be set one directly above the other so the strip emerges horizontally, as shown in Fig. 1, or they may be set side by side so the strip emerges vertically downward, as diagrammed in Fig. 2. In Fig. 1, showing horizontal feeding, the operator is pouring powder on a carrier (in this case a strip of paper) and the other operator is acting more or less as a tension guide. At the Glenn L. Martin Co. we now use rolls of accounting paper as the carrier, load it from a hopper, regulate the amount by an adjustable lip and have a take-up reel on the opposite side of the mill. The metal strip can either be peeled off the carrier or else the paper can be burned off during sintering.

If a strip of metal — say mild steel — is to be clad with a thin layer of another, the metal strip would obviously be the carrier.

Figure 2 is a schematic representation of the vertical arrangement. The hopper shown may be eliminated and the powder merely dumped in the channel between the rotating rolls. This is known as a "heavy powder feed". When the rolls turn they drag the powder through and press it to form strip. This has an advantage over conventional powder metallurgy techniques wherein the powder is pressed in a restrained die, and the pressure approaches the hydrostatic in nature. In powder rolling we only press in one direction, that is, *push* the powders together as they flow between the rolls and thus they have one degree of freedom.

When a hopper is installed, as diagrammed in Fig. 2, the powder no longer is fed between the rolls; rather, the latter pinch it and carry it through. The design of the discharge slot is important, and is shown in detail. Note that a straight chute extends from the bottom through which the powders must drop. (A vibrator is a

necessary adjunct if the powders are not free-flowing.) It is quite important that this straight drop be included in the hopper feed, particularly when cladding metals. We found that the clads can be controlled quite precisely if the drop of powder is vertical. If it is at an angle, then control of the thickness of the clad around the core materials is very difficult.

The sketch shows a possible sequence of operations. The powder comes between the rolls in a uniform thin stream, the green strip is continuously fed into the first furnace for a preliminary sinter, is cooled, cold rolled, furnace sintered, again cold rolled, furnace annealed, and given a final rolling for size or temper.

Certain variations may be made from this continuous sequence of Fig. 2. There is the possibility of coiling the green strip and then batch

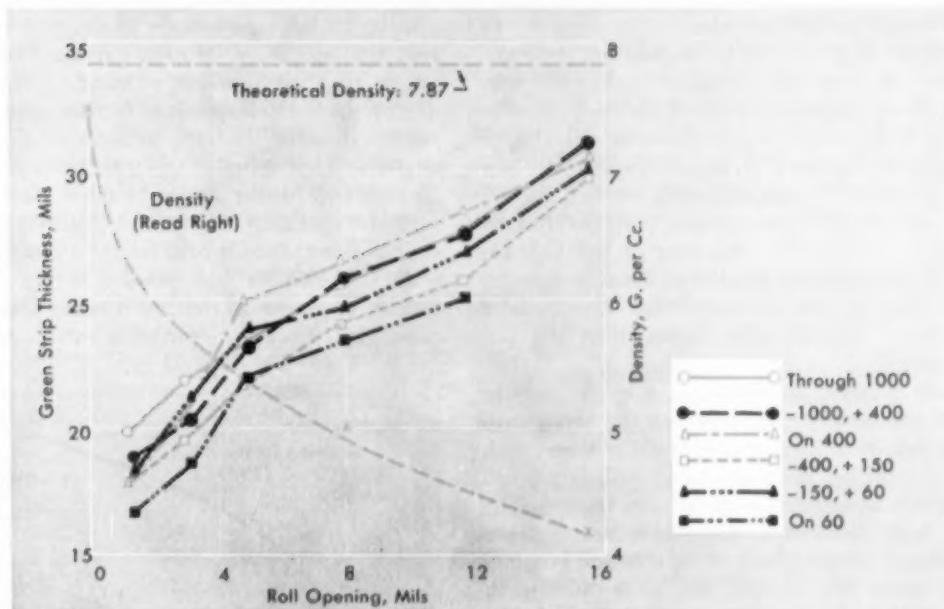


Fig. 3 - Particle Size of Iron Powder Has Relatively Little Influence on Thickness of Green Strip. Its density is largely affected by roll opening

sintering it, this to be followed by cold rolling and the other operations indicated. It is interesting to note that little if any mention has been made in the literature of the possibility of hot rolling the green strip. We have found this not only to be feasible, but absolutely necessary when working with aluminum powder. Hot rolling of green strip also avoids long sintering times, and permits much higher reductions of strip thickness before annealing becomes necessary.

Some information is available concerning the effect of mechanical variables on the thickness of the green strip. For example, take the following data on thickness of strip made from aluminum powder, fed vertically and fed horizontally, as the roll opening varies:

ROLL OPENING	GREEN STRIP VERTICAL	THICKNESS HORIZONTAL
10 mils	17.2 mils	13.0 mils
15	21.0	17.8
20	25.0	22.3
25	29.0	27.0

The differences are not wholly due to variable springback in the rolls and housings. While there is not too great a difference in thickness for the same roll opening, vertical feeding appears to crowd more metal between the rolls, and the "oversize" is greater for close settings than for more open ones. Experiments on iron powder by Naeser in Germany show that this effect is slightly exaggerated as roll diameter increases.

Likewise speed of rolling has an influence — the faster the rolls are rotating the thinner the green strip. Specifically, our experiments on 18-8 powders at Bayside with rolls set close together (zero opening) and fed from a hopper with 1/16-in. chute produced a green strip 15.7 mils thick when the rolls were driven at 10 rpm., and only 8.2 mils when at 40 rpm.

The distance between bottom of hopper chute and the rolls can vary between zero and 0.5 in. without making any difference in the green strip thickness when the rolls are running slowly (10 rpm.). At higher speeds (30 rpm.) raising the hopper the above distance reduced the green strip thickness about 15%.

Another variable in hopper feeding is the width of the opening. Here again, this item has little effect when the chute is close to the rolls and the rolls are operating at zero opening and at low speed; the green strip is about 15 mils thick. With higher speeds (40 rpm.) the wider hopper openings, feeding larger amounts of powder into close-set rolls, give much thicker green strip, less constant in dimension:

HOPPER OPENING	GREEN STRIP THICKNESS		
	MIN.	AVERAGE	MAX.
1/16 in.		8.5 mils	
3/16	11.3	12.1	12.9
3/8	15.0	20.0	25.0

Average particle size also has an effect on the thickness of green strip for various roll openings. Figure 3 from the German work with iron powder of various sizes shows that there is relatively little change in strip thickness with change in particle size for a given roll opening and that the particles through 400 mesh produce slightly thicker strip than the coarse particles (on 60 mesh). Under the conditions of the German work, especially the rigidity of the mill, one can generalize in the statement that iron powder produces strip 17 mils thicker than the roll opening.

Roll opening, however, has a large influence on the density. At zero opening the green strip with density of 7.5 g. per cc. is 95% of theoretical, but the thicker strips produced with larger roll openings are much less tightly compacted. The very high densities at the smaller openings are attributed to springback of the rolls and housing. This green strip of iron powder is quite weak so it has to be carefully handled through the presintering furnace.

Stainless Steel Strip

Stainless steel appears to be a good alloy for protecting or cladding the uranium in an "intermediate" reactor—that is, one wherein the neutrons necessary for the chain reaction are only partially slowed down. The uranium or other fissionable material inside each of these "fuel elements" may be fabricated into the element by powder metallurgical processes, and it therefore appeared desirable to study carefully the manufacture of 18-8 strip from alloy powders, its subsequent mechanical properties and its stability in contact with water or other coolant at high temperature and under intense radiation. Because of the heat generated by atomic fissioning in the center of these elements, the problem of heat transfer is also important. Obviously, if the core and protecting sheath could be made almost simultaneously by powder metallurgy methods, we would have an ideal joint for the transmission of heat.

We found that irrespective of speed of the rolls—13, 30 or 40 rpm.—the green strip was about 30 mils thicker than the roll openings when tightly or narrowly set, and proportionately less to about 20 mils thicker than the opening when the rolls were widely set—say 30 mils apart. However, there was a strong influence on quality. At the slow speed of 13 rpm. we got uniform and strong strip up to 30-mil roll opening (producing green strip 50 mils thick), but on wider

openings a large percentage of the powder was lost. Roll speeds of 30 rpm. gave uniform and strong strip up to 20-mil opening (green strip 47 mils thick). Roll speeds of 40 rpm. apparently were too high; the strip was weak along its center and not cohesive when the rolls were set 25 mils and further apart. In other words, the range for obtaining uniform strong strip is greater for the slower speeds than for the faster speeds.

As is shown for iron powder in Fig. 3, the density decreases as the roll opening increases, although not nearly to the same extent. At zero

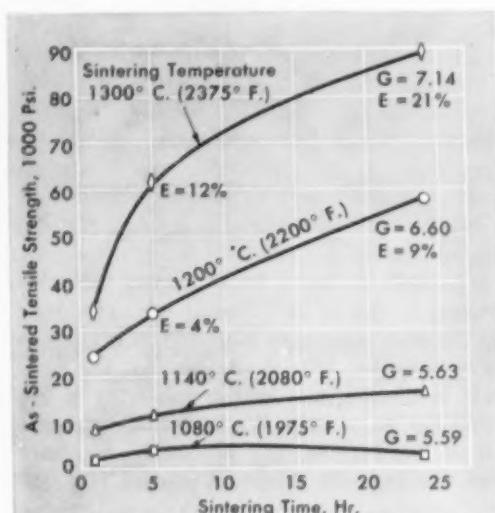


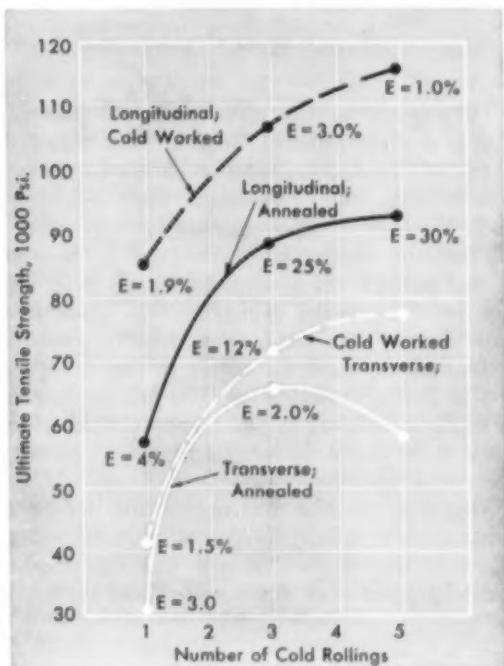
Fig. 4—Effect of Sintering in Hydrogen at Various Temperatures on the Tensile Strength and Elongation of 18-8 Green Strip. Eventual densities in g. per cc. are noted at the ends of the curves

opening the green density averages 6.8 g. per cc. (about 85% of theoretical), dropping rapidly to about 6.5 g. per cc. at roll openings of 5 mils and then more gradually to about 6.0 g. per cc. at roll openings of 25 mils. Contrary to the appearance of green strip rolled at the higher speeds, as mentioned above, 40 rpm. gave somewhat higher densities than slower speeds.

The work summarized above on iron and 18-8 was based on powder dumped on the rolls of a mill set to discharge in a vertical plane. When a hopper and chute, such as shown in Fig. 2, is used, results are somewhat different. Without going into much detail, which would be out of place in this general statement, it may be said that thickness of green strip increases much as described above with increase in roll openings

at roll speeds up to 30 rpm. (The same effect was noted, although to a less degree, on an aluminum alloy containing 1% nickel and 0.3% iron.) Thus, regardless of the metal powder, the indication is that green strip thickness is always considerably larger than the roll opening.

However, when the hopper has a $\frac{1}{8}$ -in. opening the 18-8 green strip density increases from about 5.7 g. per cc. at zero roll opening to about 6.9 g. at 4 or 5-mil roll opening (producing a 35-mil green strip at speeds up to 30 rpm.). Thus, the allowable roll opening that can be used for vertical feeding by hopper is considerably less than for the dump-type feed—a maximum of 7 mils versus 30 mils, respectively.



material for cold rolling. Five passes brought the strip into such condition that its tensile strength was 45,000 psi. and its elongation 25%.

We could get good strength by sintering stainless steel in hydrogen at high temperatures for say 24 hr. The green strip itself has considerable strength and ductility and can easily be coiled and batch sintered. It was prepared in the following way:

Average grain size of powder	-325 mesh
Hopper slot opening	$\frac{1}{8}$ in.
Roll diameter	6 in.
Speed of rolls	13 rpm.
Opening between rolls	0
Thickness of green strip	16 mils
Density	5.5 g. per cc.

Fig. 5—Tensile Strength and Elongation of Sintered 18-8 Green Strip After Various Programs of Cold Working and Annealing. Properties are much better in the longitudinal than in the transverse direction

Figure 4 shows the effect of sintering time and temperature in hydrogen on this stainless steel strip. We see that with increasing temperatures and times to 24 hr. the tensile strength increases as soon as 1200°C . (2200°F .) is reached, and there is a very sharp increase in strength with a maximum of over 90,000 psi. at 1300°C . (2375°F .) for 24 hr. Density also increases at these higher temperatures, as noted by the figures at the ends of the curves. Elongations before sintering and after all sintering up to 2080°F . were 1% or less; elongations after higher sinterings were more satisfactory, reaching 21% at the maximum. At highest strength and elongation the density is 7.14 g. per cc. or 90% of theoretical. Remember this is the green strip, as sintered, without subsequent working.

Some data on hot rolling in air at 600°C . (1100°F .) were accumulated on aluminum with 1% nickel and 0.3% iron powder added. Two passes, with rolls set at zero opening, consolidate the green strip of density 1.55 g. per cc. to 2.64, which is 96% of theoretical. A homogenizing heat treatment at 1100°F . for 2 hr. in hydrogen then produced metal of 2.76 sp. gr., slightly denser than theoretical as figured by the method of mixtures. This can be explained by the formation of a compound NiAl_3 which has a greater density than the mixed crystals, and there is enough of this NiAl_3 intermetallic formed in the strip to increase the over-all density of the strip beyond the theoretical 100%.

Sintering and Hot Rolling

Green strip is weak. In a production line, such as sketched in Fig. 2, the first sintering may be quite short—on the order of 1 min. to consolidate and strengthen the metal so that it can easily be handled for further rolling. Dr. Naeser's report on the German work indicates that green strip of iron, having a tensile strength of only 1300 psi., can be strengthened to 4500 psi. by short-time heating at 1100°C . (2000°F .) and to 5250 psi. at 1200°C . (2200°F .) Weak though this may appear to be, it was good ma-

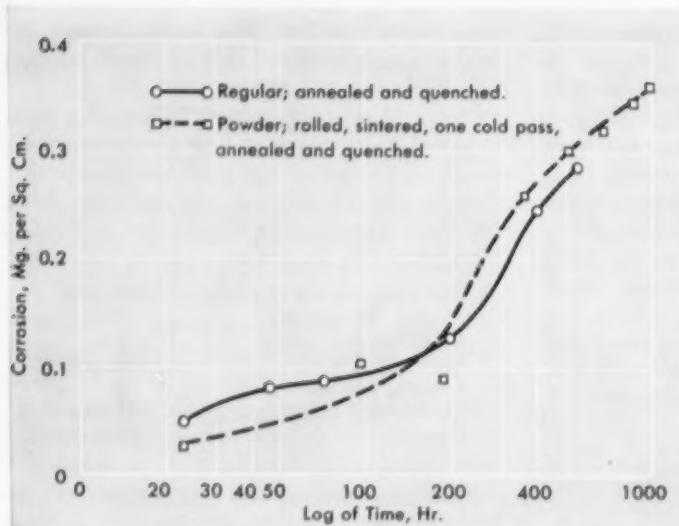


Fig. 6—Comparative Losses by Corrosion in Water at 680° F. of Commercial and Powder Metal 18-8

Cold Rolling Sintered 18-8 Strip

Figure 5 shows the effect of cold rolling sintered green strip of 18-8. The green strip was prepared under the more-or-less optimum conditions listed above and then sintered at 2375° F. for 24 hr. Following this, samples were cold rolled one, three or five passes, the rolls being set at zero roll opening for each pass. Samples were then tested in both longitudinal and transverse directions as cold rolled and others after annealing in hydrogen at 2375° F. for 2 hr.

It will be observed that there is a considerable difference in properties of the strips taken in the two directions. The maximum tensile strength attained is 115,000 for longitudinal strips and only about 80,000 for the transverse sections. In both directions the strength increased rapidly with increasing number of cold roll passes.

When the samples are annealed after being cold rolled, the strengths rise and level off for both longitudinal and transverse directions. Transverse strength may be impaired by further cold working prior to annealing. Here we again see that the longitudinal strengths are greater than the transverse for the same number of cold roll passes — about 88,000 versus 66,000 psi. at three passes. Cold worked longitudinal specimens have low elongation; after annealing the elongation attains a maximum value of 30%. Elongation is also considerably lower for the transverse specimens than for the longitudinal ones.

Finally, after making satisfactory 18-8 stainless steel strip from powder, we determined its corrosion resistance in water at 680° F. (Fig. 6).

The green powder metal strip was sintered, given one reduction in the cold rolls, annealed at 2375° F. and quenched. Comparison test pieces were made from commercial Type 302 strip, which was also similarly annealed and quenched.

Both the commercial material and the powder metal product lost somewhat less than 0.100 mg. of metal per sq.cm. of surface area in the first 200 hr. but then this state of relative passivity was broken. While the curves in Fig. 6 appear to be rising steadily after 1000 hr., the rate is steadily decreasing as will be appreciated when it is remembered that the horizontal coordinates are on a logarithmic scale.

Perhaps the real evidence of the curves is that there is little difference in corrosion resistance of the commercial strip and the powder metal product when immersed in water at 680° F.

Conclusion

This now concludes the major points which were to be discussed. The writer strongly feels that powder rolling is one of the most fascinating and unique of the modern fabrication processes. It has a great potential from all the advantages it offers. We are just now starting to get into the areas of greater promise — namely, use for nuclear fuels. In the very near future, the quantities of metal powders that are rolled may be fairly large, on the order of about 5% or more of the total market of materials for a particular alloy system. This will mean that powder rolling as a major fabrication technique will have to receive due consideration from many metal manufacturers.

Radiation Damage to Unborn Generations

Six committees of eminent scientists have reported to the National Academy of Sciences their studies of the effect of high-energy gamma radiation on genetics, pathology, weather and food supplies. A summary has been published, from which the following extracts supplement the article on "Genetic Effects of Atom Bombs" in *Metal Progress*, October, 1955.

EVERY CELL in the human body (and in every other living organism) contains a collection of tiny units called "genes" which determine the characteristics the individual is born with. Each person gets his genes from his parents, who got them from theirs, and so on. They come in pairs, one gene of each pair is inherited from the father and one from the mother.

Gene pairs are acquired thus: Sperm and egg cells have single sets of genes rather than pairs. When a sperm and egg unite to form the first cell of a new embryo, there is a new double set, half coming from the father and half from the mother. As the embryo develops, this set is duplicated over and over again so that every cell in the body of the fully developed infant has an essentially identical set of genes.

[It is believed that genes from the mother and from the father are paired, and that one is usually "dominant", although not overpowering, while the other is "recessive", although it retains some influence. In the child the result is a compromise. Thus the continual reshuffling of a fairly limited number of genes leads to the almost infinite variations, person to person.]

Every so often a gene in the sperm or egg cells changes or "mutates", in a way as yet mysterious, and the characteristic of the organism which it controls in the offspring is altered. Heat, certain chemicals, and radiation will do it. Genes in sperm and egg cells are especially vulnerable to gamma and X-radiation, and once changed, the new form is passed on as faithfully as the old one was. The processes of life are so delicately balanced that any departure from the established order of things at the cellular level is overwhelmingly likely to be for the worse. Mutations almost invariably harm the organism in which they occur, even though evolution results from a sequence of rare mutations, each of which produced an organism slightly better equipped than its ancestors to deal with the environment. But the exceptions merely prove the rule: *Most mutations in reproductive cells*

are harmful. Also, since mutant genes are usually "recessive", the harm may not be apparent for several generations. On the average, a detrimental mutation, no matter how small its harmful effect, will in the long run tip the scales against some descendant who carries this mutation, causing his premature death or his failure to produce the normal number of offspring. In this way harmful mutations are eventually eliminated from the population.

Speaking in broadest generalities, the human race at present carries a supply of recessive genes and has constantly been absorbing mutants from heat, absorbed chemical compounds, and cosmic and other natural radiation. The total supply represents a balance between the tendency of old mutants to eliminate themselves, and the tendency of new ones to appear. Any additional radiation — as from X-ray examinations or atomic bomb fallout — will produce a corresponding number of additional mutations, and this will *almost always* tip the scales in the wrong direction. It follows, therefore, that we ought to keep all our exposure to radiation as low as possible.

A population that is exposed, generation after generation, to an increased amount of radiation will experience a rising death rate and a falling birth rate because of harmful mutations, until a new equilibrium is established between the increased rates of mutation and elimination. If, in this process, the death rate comes to exceed the birth rate, the population will decline and eventually perish. At present we are extremely uncertain about the level of this fatal threshold.

[Finally the scientists estimate that the natural radiation with which the human race is in balance totals about 4.3 roentgens from inception to age 30, at which time half of the children are born. For the present generation this will be increased by 0.5 roentgen by fallout from atomic explosions. A much larger increment — 3.0 roentgens — comes to the average civilized man in his first 30 years from X-rays. It is understandable, therefore, that geneticists are much disturbed over this new state of affairs. During evolutionary processes we have adjusted ourselves to 4.3 roentgens, and now we suddenly jump this up to 7.8 roentgens, nearly double. It is to be expected that our present "defectives" will eventually be doubled to about four out of every hundred, and "extinction of the mutant genes is accomplished only through tragedy".]

Did you know that only 10% of the aluminum made in the U.S. in 1955 went into aircraft, or that the largest single use of magnesium is as an alloying metal? Innumerable postwar applications have resulted from wartime experience. (T general, Al, Mg)

The Light Metals in American Economy

By FRANCIS C. FRARY*

First let me define "light metals", for the purposes of this presentation, as magnesium and aluminum. They have other characteristics in addition to lightness: They are the only two metals in general use that are produced electrolytically. They also have strength and stability under atmospheric influences.

I will first consider, briefly, magnesium.

Magnesium—The total production of magnesium in the United States in 1955 was 61,135 net tons. Its largest single use still is as an alloying element in the production of certain aluminum-base alloys, and the steadily increasing tonnage of such alloys has naturally increased its consumption. A considerable and increasing amount of pure magnesium is also consumed in the production of titanium by the Kroll process, and the reduction of metals used in the atomic energy program, such as beryllium, thorium, uranium and plutonium.

A number of magnesium-base alloys are used for structural purposes. Their chief advantage is their greater stiffness per unit weight, especially where compression loads are important, and their high strength per unit weight in the form of castings. In aircraft, they are chiefly

used in engine housings, landing wheels, gear covers and cases, brackets, and small fuselage castings that are not highly stressed. In one modern airplane, which required a very strong structural framework, magnesium alloy sheet was used for the fuselage skin and the trailing edge of the wing, where stresses were low and stiffness important. The total amount of wrought magnesium products has grown rapidly in recent years and is now about as great as that of cast magnesium forms.

Aluminum

World production and consumption of aluminum have multiplied more than three-fold in the past ten years, and increased producing and fabricating capacity is being planned and constructed in many places. In the United States, with the largest primary aluminum-producing capacity in the world (1,500,000 tons) we are still unable to make enough to supply our own needs; last year we imported about 200,000 tons from Canada, in addition to reclaiming a large tonnage of secondary metal. It seems interesting, therefore, to look briefly at the different industries in which this tremendous American demand has developed.

Architecture—Last year the architectural field consumed about 20% of the total primary metal — about twice as much as was used in aircraft. Aluminum-clad buildings, ranging all the way from small offices to skyscrapers, have sprung into popularity within the last five years. The tallest one is the 39-story Republic National Bank Building in Dallas, Tex., containing about 750 tons of aluminum, two-thirds of which is in the exterior wall surface. The low labor cost for installation of prefabricated sections makes such

*From 1918 to 1952 Director of Research for Aluminum Co. of America; now retired. This paper was read at the Third International Light Metal Congress in Leoben, Austria, on June 7, 1956.

a wall competitive with stone or a good quality of brick; very pleasing architectural effects may also be produced. More than 200 aluminum-clad multistory buildings have been built or are under construction, and the additional floor space provided by the thinner outside wall (with good insulation) is valuable to the owner. For factory building walls, two layers of corrugated sheet with a pad of glass wool between them provide low cost and normal thermal insulation.

The aluminum windowframe was one of the early architectural innovations, pioneered in the building of the Alcoa Research Laboratories in 1929. Now between 50 and 55% of all window frames in commercial buildings and 24% of those in new residences are of aluminum. The cost is less than that of bronze and only 15 to 20% more than unpainted steel frames, and the cost of painting and repainting the steel frames soon makes them more expensive than aluminum which needs no maintenance. A variety of miscellaneous items (such as 1,500,000 ft. of extruded coping to cap brick walls, probably weighing about 1500 tons, in 1955), require a large tonnage. Aluminum fins on the pipes carrying heating or cooling fluids for heating and cooling air in buildings and dwellings consumed last year more than 3000 tons. Sheet aluminum ventilating ducts compete in economy with galvanized steel.

The transportation industry consumed nearly 20% of the total primary aluminum in airplanes, private automobiles, trucks, buses, trains and marine craft. About half was used in aircraft, nearly as much in highway transportation, and, roughly, 4% for railroad and marine equipment.

Aircraft (especially military and naval aircraft) are getting much larger and faster. Simultaneously the wings are much thinner. This has required the production of large plates of strong aluminum alloy, tapering in thickness from one end to the other, as well as sheets having integral stiffening ribs. A special mill turns out many plates 60 in. wide by 26 ft. long, tapering from $\frac{3}{8}$ to $\frac{1}{2}$ in. in thickness, and is capable of rolling such plates up to a width of nearly 100 in. The ribbed sheets are extruded on a 14,000-ton extrusion press, capable of producing a 2500-lb. extrusion 100 ft. long. Such a ribbed sheet may be up to 38 in. wide; a common size is 24 in. wide and $\frac{1}{2}$ in. thick, with ribs $\frac{1}{4}$ in. thick and $1\frac{1}{2}$ to 2 in. wide, spaced 2 to 4 in. apart. For certain types of planes, where the stiffening ribs converge instead of being parallel, such an item would be machined out of heavy



Forged Aluminum Wheel Centers for Cadillacs Come Hot From the Dies

plate, 2 to $2\frac{1}{2}$ in. thick. Powerful stretching machines, able to stretch pieces of strong alloy having a cross section up to 60 to 70 sq.in., are used to straighten heat treated sections and relieve internal strains in such plate before machining operations.

Automobiles—In 1955, the automobile industry in the United States produced nearly 8,000,000 passenger automobiles, containing from 10.8 to 191.6 lb. of aluminum each. The average was 29.6 lb. per car, giving a total aluminum consumption of about 118,000 tons. Die castings and permanent mold castings still make up the most of this. All passenger cars and most trucks have aluminum pistons cast in permanent molds, and a large proportion of the passenger cars have automatic transmissions with aluminum rotors and stators (mostly cast by the plaster process). One make of passenger car and some trucks use forged aluminum wheels, and the use of aluminum trim is growing.

Radiators with aluminum fins soldered onto brass tubing are in successful experimental use, and preliminary experiments are being carried out on all-aluminum radiators. A transition to aluminum would relieve a lot of pressure on the scarce copper supplies.

The body and framework of two out of every three of the large van-type trailer trucks are of aluminum, and its advantages in tank trucks are generally accepted. Haulage of various liquids and dry powders in bulk is increasing the demand for such aluminum tanks. The possibility of easy clean-up, so the same unit can haul fuel oil at one season of the year and ammonium nitrate fertilizer or other liquids at others, is attractive. More and more aluminum bodies are being put on medium-sized and smaller trucks as experience proves their economic advantages. Passenger buses contain from 1 to 3 tons of aluminum each, depending on their size. Thus, the total amount of aluminum used in the United States in 1955 in the automotive industry was nearly 200,000 tons (a part of this being secondary metal).

Railroads—In the railroad industry, 35 Pullman sleeping cars with aluminum superstructure were built for the Union Pacific Railroad, and construction was begun on two light trains, all-aluminum, similar to those recently built in Germany. The first of these was delivered to the New York Central Railroad in April 1956, and the other will be delivered to the New Haven Railroad later this year. A major expansion has recently occurred in the number of aluminum tank cars which have been successfully used for some years in transporting hydrogen peroxide, formaldehyde, organic solvents and concentrated nitric acid. A recent demand for concentrated ammonium nitrate solutions for fertilizer use has produced orders for more than 900 such cars within a year.

Domestic Uses of Aluminum

Consumption of aluminum in domestic items has increased greatly. Cooking utensils consumed about 30,000 tons of aluminum last year. Many utensils such as frying pans are being made of cast aluminum with electrical heating elements cast in the bottoms, so they may be connected and used outside the kitchen. Almost 5,000,000 were made last year, with about 4 lb. of aluminum in each. More than 3,500,000 electric coffee makers, averaging perhaps a pound of aluminum apiece, and 4,000,000 electric fans with an average of about 2 lb. of aluminum, were also made.

Because of the warm weather prevailing over most of our country for six to nine months each year, household refrigerators are very widely used, and stores selling meat or fresh vegetables need very large refrigerators. The evaporator units in 80 to 85% of such machines, in which the

liquefied gas evaporates and absorbs the heat, are made of aluminum; such parts as trays, shelving and inside doors are also generally made of aluminum — mostly oxide coated and often ornamented in color. More than 4,000,000 refrigerators, each containing an average of 15 lb. of aluminum, were made last year. Home freezers, designed to operate well below the freezing point and averaging 10 cu.ft. in capacity, are coming into general use for freezing and preserving many foods in the home. More than a million of these, containing about 8 lb. of aluminum each, were sold last year.

Household-type vacuum cleaners to the number of 3,300,000 consumed about 5000 tons of aluminum, and electric irons another 4000 tons. Virtually all such "irons" now have aluminum sole plates cast around the heating element. Irons intended to inject steam into the articles being pressed ("steam irons") also have aluminum water tanks and other parts.

A large part of the 100,000 tons of aluminum foil rolled last year found its way into the households of America. About half of it was thin gage, laminated with paper or plastic and used as a vapor barrier and for decorative packages for tobacco, candies, butter and cheese. About 10,000 tons, in gages from 0.0007 to 0.0015 in., were sold as "household foil"; in the home it is chiefly used for wrapping food to be cooked or to be stored in freezers. Disposable containers of aluminum foil, for cakes, pies and other pastry, and for a variety of frozen food products, had a large and increasing market. This growing demand has required large additions to our foil manufacturing capacity.

Electrical industry consumes steadily increasing amounts of aluminum. The present shortage and high price of copper have accentuated this demand, which now totals about 200,000 tons per year. In addition to the general use of "aluminum conductor, steel reinforced" for high-tension transmission lines, insulated power supply and feeder cable has attracted much attention. The latter has been officially approved in all sizes from branch circuits up to 2,000,000 circular mils (about 2 in. diameter), and it is now commercially available covered with all the principal kinds of insulation. Since 1947, all the new factories and office buildings built by Aluminum Co. of America have used aluminum wiring exclusively; more than \$200,000 was saved thereby in one large rolling mill. Aluminum busbars are commonly found in secondary distribution systems in factories and office buildings. Western



High Heat Conductivity and Excellent Castability Are Requirements Met in Aircraft Engine Cylinder Heads

Electric Co., the world's largest manufacturer of telephones and telephone equipment, has announced its plans to convert gradually from copper to aluminum, beginning with about 10% of its consumption. The Bell Telephone Co. already has successful experience with a "sample" installation of more than 5000 miles of aerial telephone cable, varying in capacity from 20 to 3000 pairs of aluminum conductors per cable. Switchboard equipment made of light metal is also being tried.

More and more aluminum is going into transformers and motors, wherever space is not a critical requirement. General Electric Co., uses aluminum for the rotor and field coil windings

of all the refrigerator motors it makes. The substitution of aluminum for the small brass parts on electric light bulbs and in lamp sockets consumes 8000 tons of sheet a year. Two of the large electric utility companies have installed aluminum-sheathed, high-voltage aerial power cable. In airplanes, aluminum naturally replaces copper in most of the electrical equipment.

Military purposes (including aviation), which required about 90% of the available metal during World War II, now account for only about 10% of the demand. In spite of the merits of magnesium, stainless steel and titanium, aluminum is still the favorite light metal of the aircraft designer and the principal metal used in planes.



Most Modern Equipment Is Available to Produce Sheet and Other Mill Shapes for American Producers

An Over-all View

There are several reasons for the tremendous civilian demand for aluminum that has developed in the United States since the end of the last war. In the first place, the manufacture of aircraft parts during the war, in thousands of large and small plants, taught a whole new group of managers and workers the fabrication and advantages of aluminum. Many of them saw uses for it in their peacetime business when it became available again to civilians.

In the second place, a great deal of time and effort had been spent before the war in introducing aluminum, experimentally, in a great variety of plants and processes. Technical laboratory and engineering designs had revealed many of its advantages. Experience was being accumulated before the war, and more was accumulated under conditions of intensive operation during the war. The general success and advantages of

these applications were very interesting to the managements involved; consequently the need to repair and reconstruct old plants and equipment after the war, and to build new ones, provided the opportunity to apply this information. Favorable price relationships and shortages in competing materials have naturally also increased the demand for aluminum.

With greatly increased supplies of the metal and plenty of experienced fabricators in all lines, the stage was set for the tremendous and unexpected increased consumption of all forms of the metal. This has resulted in still further increases in productive and fabricating capacity, in an effort (so far unsuccessful) to meet this demand. The industry foresees a continuous and still rapid increase in output, as commercial experience with the metal accumulates in all branches of industry, and more and more manufacturers learn how the metal can be used to their advantage in their processes or products. ☐



Correspondence . . .

More on Aluminum-Silicon Pistons

LEEDS, ENGLAND

We were very interested in the report by J. C. Wagner on the modification of hypereutectic aluminum-silicon alloys by dilute copper in the June issue of *Metal Progress*.

My company carried out considerable investigation some three years ago to determine the best method of reducing silicon particle size and to achieve better distribution. Of the various methods tried, the most consistent was the use of phosphor copper, and since that date all production melts have been so treated.

Phosphor copper is much more effective and much more pleasant to use than phosphorus pentachloride and improves machinability; thus Mr. Wagner confirms the results which we have found in practice in the production of many thousands of complex 22% Al-Si alloy pistons.

E. V. DEWHIRST
Chief Metallurgist
Specialloid Ltd.

LAKE CITY, MINN.

When reading Mr. Wagner's article, "High-Silicon Aluminum Casting Alloy", I was puzzled by the statement that the 22% silicon-aluminum alloy was being used in pistons in Europe while no mention was made of any piston production in this country. The only inference possible is that no pistons are being made from high-silicon alloy here and this is not the true picture.

Vanasil aluminum alloy is a 21 to 23% silicon alloy which has been produced and used in pistons in this

country since 1939. During the war it was used extensively in the pistons of small air-cooled engines for the armed services, and we have produced many, many pistons in this alloy for both diesel and smaller engines, since acquiring the Vanasil rights in 1948.

The Vanasil alloy and the high-silicon alloy used in Europe have similar characteristics.

W. C. CHENEY
Vice-President
Gillett & Eaton, Inc.

Metallurgists Wanted Badly

EAST LANSING, MICH.

The colored insert in the July issue of *Metal Progress* will, in my opinion, do much good if the members of follow your advice, cut it out and give it to some bright youngster of high school age. As a matter of fact, the same thing could have been said of your editorial of December 1935, entitled "Trained Metallurgists Needed". The youngsters born that year will this year be graduating from college. We seem to have progressed from "Needed" to "Wanted Badly"!

We must be much more aggressive in going out after the youngsters. As Prof. R. M. Brick wrote two years ago, metallurgy needs "a huckster". Consequently if I were writing the colored insert in the last issue I would have considerably expanded the sections on Opportunities and on Advancement. I would also have enlarged upon your remark on the opportunities for women in the field. While you have indicated there are

desirable places open to them, it might have helped to point out that some women have been outstandingly successful.

In a good deal of the written material on this topic the metallurgists seem to be on the defensive — though there is no good reason for it. The metalworking industry including all of its phases is certainly the leading industry not only here but in every industrial nation. Because of our general failure to emphasize on every occasion what the metallurgist is capable of doing we are unable to convince many, even in our own industry, that the metallurgist can more than pay his way. I have in mind an instance of that in the forging industry. I know of a city in the Midwest where there are one captive forge shop and five jobbing shops. Only the captive shop has a metallurgist! The jobbing shops have talked about it but still have no metallurgical control of their operations.

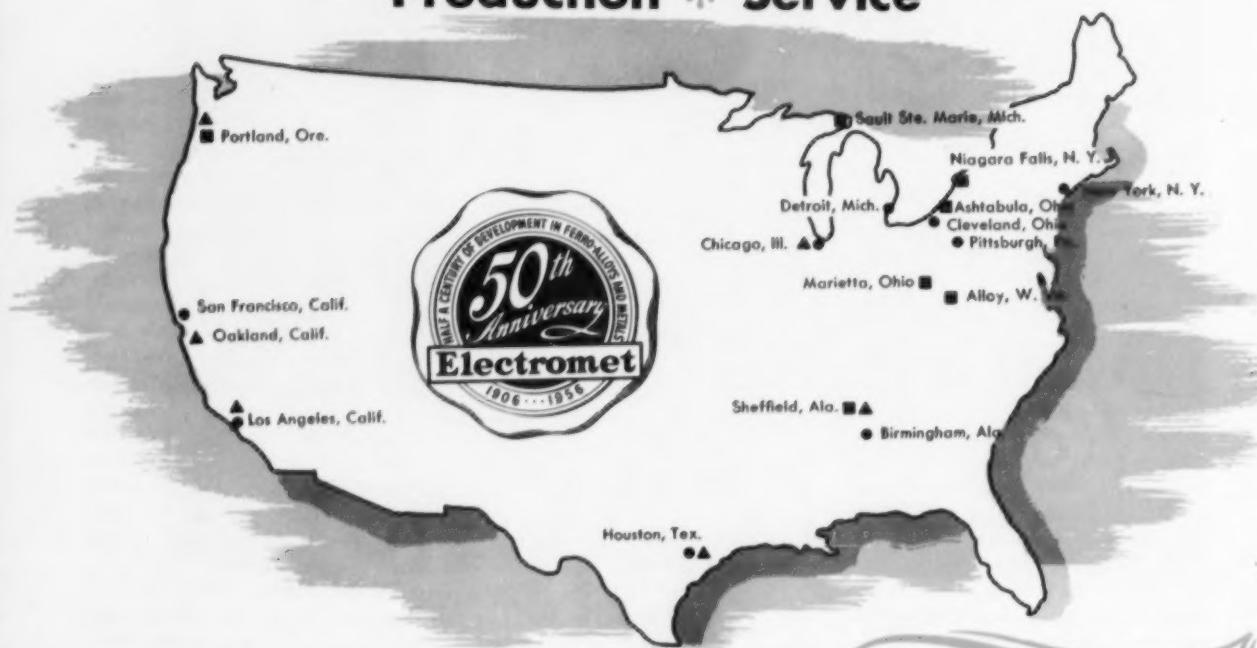
I do not know wherein the fault lies but something is certainly wrong. When these and similar industries put in metallurgical departments it will put a terrific burden on the number of available metallurgists.

In this country we have always risen to the occasion; if anything were needed badly enough we have contrived the means to get it. Thus, one of these days knowledge of the need will trickle through to the high schools. Certainly let us hope that some morning in 1977 we will not open our copy of *Metal Progress* to read "Supply of Metallurgists Desperate"! A. J. SMITH

Head, Department of
Metallurgical Engineering
Michigan State University

You Benefit from ELECTROMET'S

through Research * Development
Production * Service



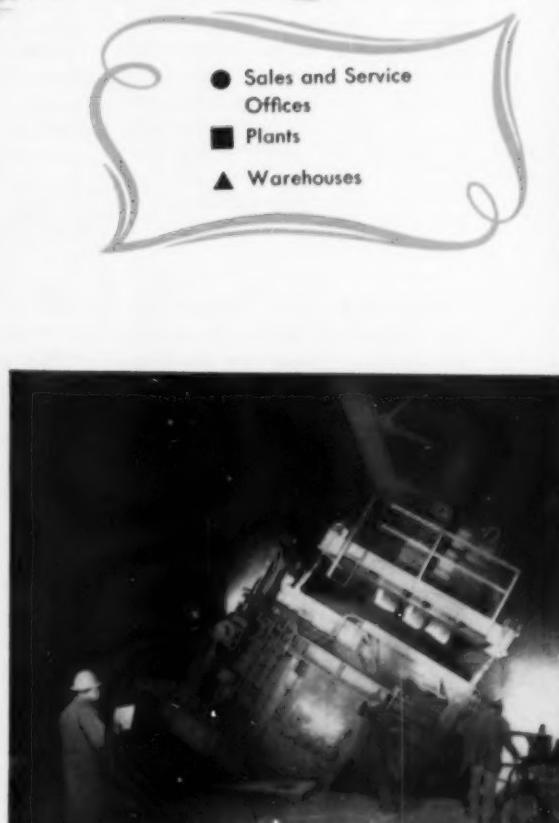
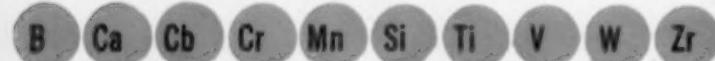
For 50 years ELECTROMET has produced ferro-alloys and metals essential in the production of steel, iron, and non-ferrous metals. Research and development by ELECTROMET during these 50 years have provided the trade with new and better alloys and metals to meet specific needs. Increased emphasis on research and development promises continued benefits in the future.

The ELECTROMET story is one of steady growth and progress for the benefit of the metal industries. When you buy from ELECTROMET, you get the best in alloys and service plus the advantages of long manufacturing experience and extensive research.

Here are some of the advantages you get from ELECTROMET's integrated programs.

Competent Metallurgists and Sales Engineers

Nine sales and service offices are strategically located in the major steel producing centers as shown on the map above. If you have a problem on metals or alloys, let one of our experienced metallurgists or sales engineers help you. He will be glad to assist you with any problems on the production of quality steels, irons, and non-ferrous metals. Simply telephone or write the ELECTROMET office nearest you.



50 Years of Experience

Continuing Research and Development

Since 1906 ELECTROMET has carried on a three-way program of research, development, and technical service. More than 300 skilled research scientists, engineers, and technicians work in ELECTROMET's Metals Research Laboratories and Development Laboratories at Niagara Falls (shown here). This program provides you with new ferro-alloys and metals, better ways of using them, and new and improved alloy steels and irons. Innovations are fully developed in our laboratories before they are offered commercially.

Wide Range of Alloys to Meet Your Needs

Over 50 different products are manufactured to meet the regular requirements of the metal industry as well as the special needs of customers. This wide range of high-quality ferro-alloys and metals is the result of 50 years of research, development, and service by ELECTROMET. ELECTROMET offers the widest selection of ferro-alloys and metals to meet your specific requirements.

Seven Modern Plants—4 With Own Power Facilities

Our plants have been greatly expanded and modernized to meet the current demands for ferro-alloys and metals. The recently completed plant at Marietta, Ohio, is the world's largest ferro-alloy plant. Company-owned power facilities at four of the plants assure a constant supply of power for efficient production. Prompt shipment of ELECTROMET ferro-alloys is assured from all seven plants, and from six warehouses conveniently located to serve you.

World Wide Ore Sources

The availability of ores, and other raw materials is assured by ELECTROMET's diverse facilities, including mines and ore milling plants owned by UNION CARBIDE. Helping to assure adequate ore supplies are the ore buying facilities of Union Carbide Ore Company, a Division of Union Carbide and Carbon Corporation. Ores come from the far corners of the earth to ELECTROMET's plants. On this simplified map of the world, symbols for the chemical elements indicate a few of the major sources of alloy ores.

ELECTRO METALLURGICAL COMPANY

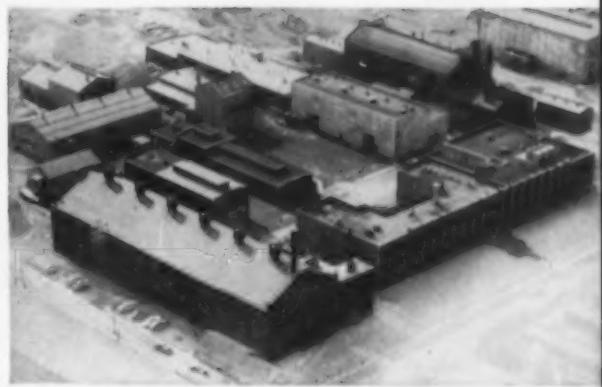
A Division of Union Carbide and Carbon Corporation

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of Union Carbide and Carbon Corporation.



Personal Mention



Stanislaus Skowronski

STANISLAUS SKOWRONSKI Ⓣ, research engineer at the Raritan Copper Works of the International Smelting & Refining Co., Perth Amboy, N. J., a subsidiary of the Anaconda Co., retired recently on the eve of his 75th birthday.

Born in Switzerland, Mr. Skowronski received his technical education at Massachusetts Institute of Technology, graduating in 1904. Two years later he joined the American Smelting and Refining Co. in Perth Amboy, as a chemist, but left in 1912 to join the International Smelting & Refining Co.'s Raritan Copper Works. At his retirement, Mr. Skowronski had been associated with the company for 44 years.

Mr. Skowronski has written many articles on copper, including the chapter on copper in the new Encyclopedia Americana. He also has lectured extensively and served as an adjunct professor at the Polytechnic Institute of Brooklyn for 25 years.

A member of numerous technical societies, Mr. Skowronski was active on the early B committees of the American Society for Testing Materials and has served as his company's representative to that society for 30 years. He is also founder of the Technical Societies Council of New Jersey, serving as president in 1944 for one year, and is a past chairman of the New York Chapter Ⓣ.



Kempton H. Roll

The Metal Powder Association, New York, has appointed KEMPTON H. ROLL Ⓣ as the first full-time executive secretary and treasurer of the organization.

Mr. Roll received his metallurgical education at Carnegie Institute of Technology and Yale University, graduating from Yale in the fall of 1944. After two years' service in the Navy, he joined the Magnolia Metal Co., Elizabeth, N. J., as a research and production metallurgist, but left the company in 1948 to join the Lead Industries Assoc. and Metal Powder Assoc. as staff metallurgist. At the time of his new appointment, Mr. Roll was technical director of both the Metal Powder Assoc. and Lead Industries Assoc. During this period, he continued his studies and in 1953 received a master's degree from the Polytechnic Institute of Brooklyn.

Mr. Roll has written numerous technical papers on lead and its alloys and on powder metallurgy. He is also active in many technical organizations; currently he is chairman of both the New York Chapter Ⓣ and the New York powder metallurgy group of the American Institute of Mining, Metallurgical and Petroleum Engineers. He served as general conference chairman of the 1956 International Corrosion Conference sponsored by the National Assoc. of Corrosion Engineers.

Paul C. Mortenson Ⓣ has joined Vickers, Inc., Detroit, as chief engineer, ground mobile products. Mr. Mortenson was administrative engineer, western hemisphere, for Massey-Harris-Ferguson, Inc., Racine, Wis., before coming to Vickers.

Robert C. Wayne Ⓣ has been appointed to the newly created post of advertising and public relations manager, Southwestern Engineering Co., Los Angeles. Prior to his present position, Mr. Wayne had been associated with the Surface Combustion Corp., Toledo, Ohio, for eight years as advertising manager for the company's industrial divisions.

Robert B. Winder Ⓣ is now a sales engineer in the Detroit office of the steel and tube division, Timken Roller Bearing Co., Canton, Ohio. A graduate of Wayne University, Mr. Winder recently completed a course of sales training in Timken's steel and tube division.

A. H. Davis Ⓣ has retired from his position of works manager at the R. K. LeBlond Machine Tool Co., Cincinnati. Mr. Davis joined the firm in 1935 as assistant works manager and was named works manager in 1953.

John B. Giacobbe Ⓣ, formerly plant metallurgist at the Superior Tube Co., Norristown, Pa., has been assigned to direct the nuclear products division of Superior Tube. This new division will be located in Trappe and Phoenixville, Pa.

A. R. Attebury Ⓣ has retired as district manager of the New York steel and tube division of Timken Roller Bearing Co., Canton, Ohio. Mr. Attebury, who has been associated with Timken for 22 years, will be retained by the company as a sales consultant.

G. B. Wadsworth Ⓣ is now a metallurgist with Combustion Engineering, Inc., Chattanooga, Tenn. A 1954 graduate of Birmingham-Southern College, Mr. Wadsworth previously worked as a research assistant in physical metallurgy at Oak Ridge National Laboratory.

Robert N. Lynch () formerly sales manager of Park Chemical Co., Detroit, has been appointed sales manager of the Industrial Heating Equipment Co., Detroit.

John L. Miller () has assumed new duties as director of defense activities for the Firestone Tire & Rubber Co., Akron, Ohio. Dr. Miller joined Firestone in 1941, serving successively as chief metallurgist, assistant production manager of Firestone Steel Products Co., and finally as manager of the defense research division after its organization in 1950.

Bradley B. Evans () was elected president of the Alloy Casting Institute at the Institute's annual meeting in Hot Springs, Va., last summer. Mr. Evans is sales manager of Empire Steel Castings Inc., Reading, Pa. At this same meeting, E. A. Schoefer () was re-elected executive vice-president and treasurer of the Institute.

Henry J. Wesolowski () is now working in the materials and methods engineering department of the electronic systems division at Sylvania Electric Products, Inc., Waltham, Mass.

Garrett B. LeVan () has been appointed manager of rod and bar operations for Mallory-Sharon Titanium Corp., Niles, Ohio. Prior to his recent appointment, Mr. LeVan was general manager of the Titusville, Pa., plant of Universal-Cyclops Steel Corp.

William Wilson () has been named to the newly created post of director of research and development at A. Finkl & Sons Co., Chicago. Mr. Wilson was formerly supervisor of metallurgy at Ecko Products Co., Chicago, and a research metallurgist at the Armour Research Foundation of Illinois Institute of Technology.

Robert J. MacDonald (), formerly principal metallurgist at Battelle Memorial Institute, Columbus, Ohio, is now senior metallurgist with the Clevite Research Center, Cleveland.

Craig O. Malin () is now a research engineer at the Rocketdyne Div., North American Aviation, Inc., Canoga Park, Calif.

SEPTEMBER 1956

Stop Aluminum Corrosion!

Insure Paint Adhesion

Provide Ornamental Finish

TURCOAT
4178

(Aluminum Surface Conversion Coating)

DOES ALL THREE! ... Fixes Immediately, Too

Here's a process that provides aluminum with an ornamental, paint-gripping, corrosion-resistant coating...and does it faster and better!

Turcoat 4178 works on the surface conversion principle...that is, the coating is partially derived from the metal itself. Thus, coating and metal are firmly interlocked...even in tiniest crevices. The coating is a light golden color that imparts a special beauty when used for decorative purposes.

One user reports that square footage processed has doubled since the installation of Turcoat 4178. Key to this speed is the manner in which the coating "sets" and becomes non-smearing immediately. Drying is unnecessary. Parts can be further processed without any delay in production! Moreover, the coating is uniform. There are no light, tell-tale untreated sections around welds, corners or holes.



Fixes Immediately, Too

The Turcoat 4178 Coating becomes non-smearing immediately upon withdrawal from processing. Drying is unnecessary. Parts can be handled freely while still wet without danger of smearing or streaking coating.

MEETS GOVERNMENT SPECIFICATION

Meets Government Specification MIL-C-5541.



EASY TO CONTROL

Simpler titrations... Great latitude in solution strength. Eliminates need for constant complicated control.



EASY TO USE

Apply by immersion, spray washer or hand methods. Gold color gives visual control over processing.



Write for detailed technical literature.



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Please send me detailed technical information on Turcoat 4178.

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TITLE _____

MP

Manufactured in Canada by B. W. Deane & Co., Montreal

World's



BATTERY OF CLEAVER-BROOKS EVAPORATORS IN ACTION—Revere Silicon Bronze was chosen for these evaporators and their component parts because of its high corrosion resistance and non-contamination properties, great strength and weldability. All of the components, as well as the 4 evaporator shells, are made of Revere Silicon Bronze Alloy No. 420.



ONE OF THE 4 EVAPORATOR SHELLS made of Revere Silicon Bronze, fabricated and installed by CLEAVER-BROOKS MFG. CORP., Waukesha, Wisconsin.



EIGHT TUBE SHEETS LIKE THESE were used in the Bermuda installation . . . 2 per evaporator. Each tube sheet, made of Revere Silicon Bronze, is 86" in diameter, 1 $\frac{1}{4}$ " thick and weighed approximately 1,360 lbs. after drilling.

Largest

VAPOR-COMPRESSION SEA WATER DISTILLATION PLANT

Made and installed by CLEAVER-BROOKS

*... Vital distillation units fabricated from
REVERE SILICON BRONZE*

This plant installed at the Kindley Air Force Base in Bermuda has a total daily capacity of 200,000 gallons and eliminates the dependence of the Base on rainfall or shipment of water by tankers.

Distilled water is produced in the ratio of 300 lbs. to each pound of Diesel fuel. Total costs are estimated at \$1.25 per thousand gallons of distilled water. Nearly every component part made by Cleaver-Brooks is about twice the size of its largest previous counterpart. For example, the evaporators are 16½ feet high. Each, with its component parts, weighs approximately 40,000 lbs., the empty Revere Silicon Bronze shell alone accounting for 28,000 lbs.

There is an interesting story behind the development and manufacture of this equipment. The four huge pressure vessels had to be fabricated of Revere Silicon Bronze Alloy No. 420. Knowing Revere's wide experience in welding copper-base alloys, Cleaver-Brooks called in a Technical Advisor, and gave him a complete set of blue-

prints of the vessels, with a request for suggestions regarding joint design and welding techniques. He in turn consulted the Welding Section of the Revere Research Department. Their recommendations were adopted, and the customer reported that the original estimate of welding time had been cut considerably, reducing production costs correspondingly.

The Revere Technical Advisory Service is glad to collaborate on problems involving the specification and fabrication of copper and copper-base alloys, and aluminum alloys. See the nearest Revere Sales Office.

REVERE COPPER AND BRASS INCORPORATED

*Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.*

*Mills: Baltimore, Md.; Brooklyn, N. Y.;
Chicago, Clinton and Joliet, Ill.; Detroit,
Mich.; Los Angeles and Riverside, Calif.;
New Bedford, Mass.; Newport, Ark.;
Rome, N. Y. Sales Offices in Principal
Cities; Distributors Everywhere.*



THE STEAM SEPARATORS are identified by their conical tops and directional vanes. They are of the cyclone type, which is a patented feature of CLEAVER-BROOKS evaporators, and remove entrained water from the steam, thus preventing contamination of the fresh water coming from this unit. The result is an extremely high purity of the fresh water product.

The rectangular objects at rear of photograph are the "Downcomers" which bring water down from the top of the steam separator. The tubes in left foreground are "Hotwells," which receive the distilled water discharge from the evaporator shell.



look at these advantages of **IRIDITE[®]** FINISHES

for
**CORROSION-RESISTANCE,
PAINT BASE on
ALUMINUM and MAGNESIUM**

**TYPICAL
APPLICATIONS**



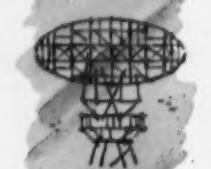
Aircraft and Missile Parts



Automobile Hardware



Outdoor Furniture



Communications Equipment



Marine Equipment



EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

IRIDITE #14 and #14-2 (Al-Coat) for ALUMINUM

Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection. Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE #15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

APPROVED UNDER GOVERNMENT AND INDUSTRIAL SPECIFICATIONS

SEE FOR YOURSELF WHAT IRIDITE CAN DO . . . SEND SAMPLE PARTS FOR FREE PROCESSING. Look at the results, test the protection, evaluate the savings. Also write for handy Reference File of the most complete data published on chromate conversion coatings. Or, for immediate information, call your Allied Field Engineer. He's listed under "Plating Supplies" in your classified phone book.

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4004-06 E. MONUMENT STREET • BALTIMORE 5, MD

Manufacturers of Iridite Finishes for Corrosion Protection
and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals.
West Coast Licensee—L. H. Butcher Co.



Personals . . .

Henry R. Clauser  has assumed the post of editor of *Materials & Methods*, New York. Formerly managing editor, Mr. Clauser has been with *Materials & Methods* for more than 11 years. He came to the staff in 1941 and after a short time left to join the U. S. Army. Returning in 1946, he served as associate editor until his appointment as managing editor in 1950.

John H. Shue, Jr.,  was promoted to metallurgist technician, working with the staff heat treat engineer, at Caterpillar Tractor Co., York, Pa.

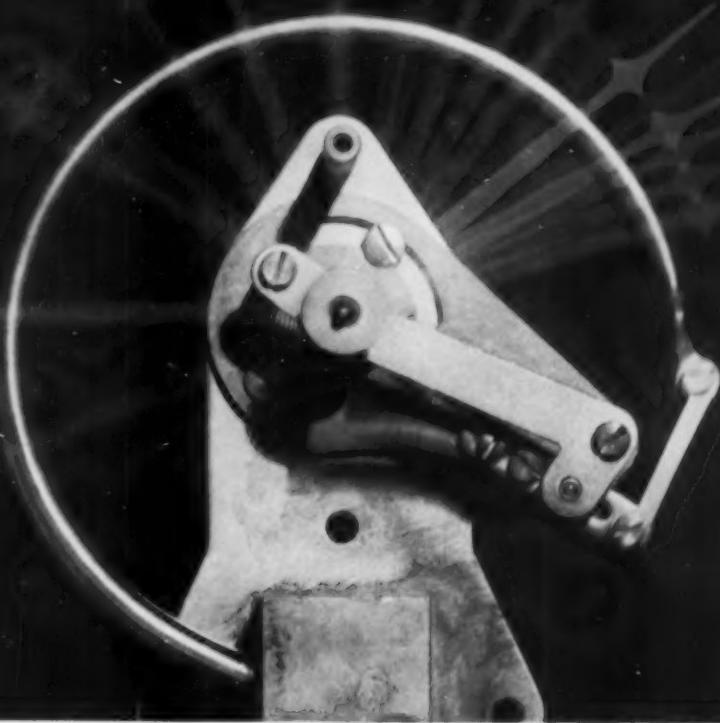
Walton S. Smith  has retired as vice-president in charge of manufacturing of Metal & Thermit Corp., New York, after 37 years with the company. Joining Metal & Thermit in 1919 as a mechanical engineer, Mr. Smith became assistant superintendent of the Carteret, N. J., plant in 1925 and superintendent in 1937. He was elected vice-president in 1942 and a year later became a director of the company. Mr. Smith will continue as a director and also as a consultant for the company.

Rudolph A. Schatzel  has been elected president of the American Society for Testing Materials for a one-year term. Mr. Schatzel is vice-president and director of engineering, Rome Cable Corp., Rome, N. Y., a post he has held since 1945. Howard C. Cross  has been elected a director of the American Society for Testing Materials. Mr. Cross is assistant technical coordination director, Battelle Memorial Institute, Columbus, Ohio, and has been with Battelle since 1929.

T. F. McCormick  formerly staff metallurgist at the Pittsburgh office of the Aluminum Co. of America, has been promoted to the post of assistant chief metallurgist. W. E. King  another staff metallurgist in the Pittsburgh office, has been named chief development metallurgist, and K. B. Baker  formerly chief metallurgist at the Edgewater, N. J., Works, is chief control metallurgist in Pittsburgh.



Non-Habit-Forming



Pressure gage courtesy J. E. Lonergan Co., Philadelphia 6, Pa.

Beryllium Copper Tubing by Superior

This unusual term describes perfectly one of the most important properties of beryllium copper tubing. The Bourdon tube shown above is an excellent example. Once the beryllium copper tube is in the gage, it "remembers" its job and acquires no new habits. It yields constantly to pressure and as constantly returns to its original position without taking a new "set."

Beryllium copper tubing by Superior has this and many other important characteristics to a marked degree, such as hardenability, corrosion and fatigue resistance, thermal and electrical conductivity. It is easy to fabricate, it is nonmagnetic.

Beryllium copper tubing lends itself to a wide variety of applications. It can be severely worked to form convoluted flexible waveguides and bellows. Cold drawn to specifications, followed by proper hardening, it

makes an excellent aircraft antenna, with the strength to withstand thousands of hours' vibrating in 100 mph winds. Used as a contact roll in a business machine collator, it is wear and corrosion-resistant, and a good electrical conductor. Or, as above, shaped for use as a Bourdon tube, it is tough, ductile, durable—and holds its original shape.

Superior produces tubing in over 63 analyses . . . in stainless, alloy and carbon steels, nickel and nickel alloys, beryllium copper, titanium and zirconium. Let Superior's tubemanship and experience help you solve your tubing problems. You'll like the service and the products—they are habit-forming. Send for your free copy of Data Memorandum No. 7 on beryllium copper tubing. Write Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

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All analyses .010 in. to $\frac{1}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD

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Since 1930, when the introduction of Malleabrasive revolutionized blast-cleaning, there has been only one MALLEABRASIVE! MALLEABRASIVE was developed through exhaustive research. Its leadership has been maintained through continuing research and improvement.

- Today there is still only one genuine MALLEABRASIVE.
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- MALLEABRASIVE is produced only by manufacture under the full and complete MALLEABRASIVE process—used by Globe exclusively.

The qualities that make Malleabrasive distinctively different have made it the most widely used premium abrasive in the world today. In hundreds of plants it has made important reductions in blast-cleaning costs. Undoubtedly it can do the same in yours. At least, why not investigate its possibilities? Write us.

THE GLOBE STEEL ABRASIVE COMPANY
MANSFIELD, OHIO

*Subsidiary of Pittsburgh Crushed Steel Co., Pittsburgh, Pa.
Also sold and recommended by Pangborn Corp., Hagerstown, Md.*

MALLEABRASIVE®

Personals . . .

Clemens C. Sutinen has joined the staff of the Mannesmann-Meer Engineering and Construction Co., Easton, Pa., as technical sales engineer with the powder metallurgy equipment division, representing the interests of Simetag GmbH, Moenchen-Gladbach, Germany, powder metallurgical subsidiary of Mannesmann-Meer. Mr. Sutinen formerly was associated with Welded Carbide Tool Co., Inc.

L. F. Bledsoe, Jr. was recently promoted from project engineer in the atomic power design division of the Newport News Shipbuilding & Dry Dock Co., Newport News, Va., to technical assistant to the manager of the atomic power installation division of the company.

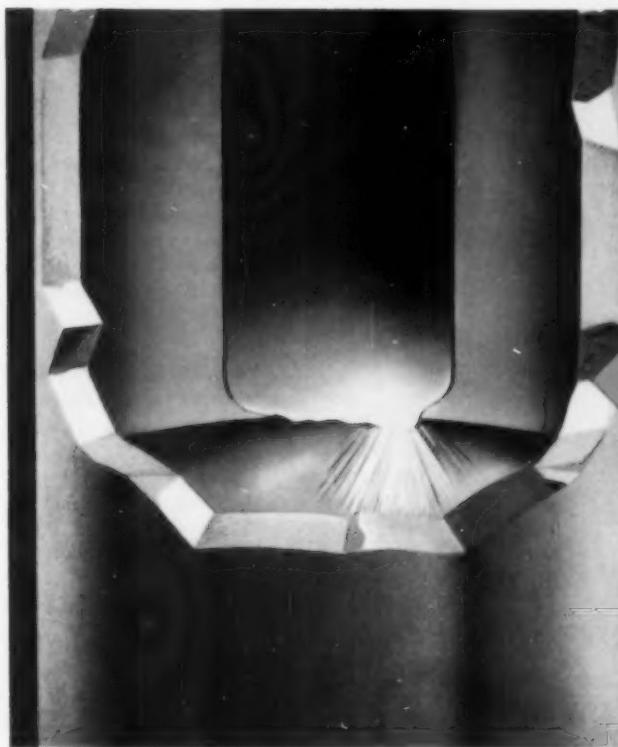
H. A. Anderson has been added to the staff of the industrial furnace division of the Gas Machinery Co., Cleveland, in the capacity of staff engineer. Mr. Anderson was formerly employed by Lindberg Industrial Corp., Chicago.

Herbert A. Jahnle has been released from the U. S. Army Chemical Corps, Dugway Proving Ground, Dugway, Utah, and is now a metallurgical engineer with the Budd Co., Philadelphia.

William J. Stewart has been transferred from the Washington district sales office of Youngstown Sheet & Tube Co. to the Cincinnati district sales office.

John R. Rink, recently released from active duty in the U. S. Army, is presently employed as technical service metallurgical engineer with Inland Steel Co., East Chicago, Ind. While in the Army, Mr. Rink served as a metallurgical engineer in the ballistics research laboratory at Aberdeen Proving Ground, Aberdeen, Md.

N. A. Wagner has been transferred from the Reynolds Metals Co. extrusion plant in Grand Rapids, Mich., to the new Reynolds extrusion mill in Richmond, Va. He will be manager of the metallurgical department in the new plant.

NRC**VACUUM
CONSUMABLE
ELECTRODE****ARC FURNACES**

**In NRC Arc Furnaces
We Have Melted...**

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Mo
Nb
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Who OPERATE Them!**

With an NRC Vacuum Arc Furnace you can now melt — economically and reliably — refractory and reactive metals and alloys. Because each of these metals behaves differently, satisfactory design of vacuum arc furnaces is unusually dependent upon operating experience. Built into your NRC Vacuum Arc Furnace are features which result from the inti-

mate familiarity gained from building and operating such units for more than a decade. For instance, the extra-safe NRC mold design reduces the danger of mold burn-through.

If you are considering the purchase of a vacuum arc furnace — laboratory, pilot plant, or production size — we would like to point out the design features of an NRC furnace which will assure you dependable, efficient, and safe operation. Use the coupon below.

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Wilson Diamond "Brale"** Penetrators



- A Minor load penetration
- B Major load penetration
- C Linear measurement of penetration increase

WILSON "BRALE" Penetrator

* WILSON Diamond "Brale" Penetrators are precision ground under high magnification to assure mathematical and microscopic accuracy. Each is standardized on test blocks and rigidly inspected at the WILSON Standardizing Laboratory.

Because of this meticulous attention to manufacturing detail, WILSON Diamond "Brale" Penetrators provide the extreme accuracy demanded of an instrument where the difference between a single degree of "ROCKWELL" reading is but 0.00008" penetration.

Special "Brale" Penetrators are available for testing unique areas—the pitch line of gears, for instance, or high temperature testing. N "Brale" Penetrators are supplied for use with WILSON "ROCKWELL" Superficial Testers.

A WILSON expert on hardness testing is never more than a few hours away. Prompt WILSON service guarantees top performance from WILSON equipment.

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ACCO

Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE



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for
Better Value

Personals . . .

Joseph J. White has been named director of research and metallurgy at Erie Forge & Steel Corp., Erie, Pa. Mr. White will be assisted by George E. Danner, newly appointed assistant director of research and metallurgy.

Joseph J. Tompos, a recent recipient of a master's degree in metallurgy from Ohio State University, has returned to the U. S. Steel Corp. as supervising technologist, high strength steels, at the applied research laboratory in Monroeville, Pa.

Arnold S. Grot has been named chief metallurgist for Edward Valves, Inc., East Chicago, Ind., a subsidiary of Rockwell Mfg. Co. Before coming to Edward Valves ten years ago, Mr. Grot was chief metallurgist for Taylor Forge and Pipe Works, Cicero, Ill.

Burns George, vice-president of sales, Vanadium-Alloys Steel Corp., Latrobe, Pa., has been elected a director of the Washington Steel Corp., Washington, Pa. Mr. George has been with Vanadium-Alloys Steel since 1923 and is also a director of that company and Vanadium Alloys Steel Ltd., London, Ont.

Yeshwant P. Telang recently was promoted from supervisor, quality analysis section, specialty foundry, Ford Motor Co., Dearborn, Mich., to research metallurgist, research and development department.

Samuel Storchheim is now assistant chief, materials section of the Glenn L. Martin Co., Baltimore. Mr. Storchheim was formerly associated with the atomic energy division of Sylvania Electric Products Corp., Bayside, N. Y.

Lloyd R. Cooper has been promoted to chief metallurgical engineer of the Heppenstall Co., Pittsburgh. Joining Heppenstall in 1942 as a research metallurgist, Mr. Cooper has served as director of research, chief metallurgist of the Eddystone, Pa., plant and more recently as assistant chief metallurgical engineer of the company.

Johns-Manville organizes to give you better insulation service

New and separate insulations division created to provide industry greatly improved Sales and Engineering service to meet modern problems

- Johns-Manville is now concentrating all industrial insulation operations within a new, fully integrated insulations division. This greater specialization makes possible the most complete insulation service available to industry. It consists of—



As co-ordinator of J-M's extensive research-engineering-manufacturing facilities, he offers you outstanding insulation training and experience.



proper finishes, weatherproofing and securement. His highly specialized knowledge makes possible an intelligent recognition and handling of your individual insulation requirements.



estimators and mechanics trained in J-M application techniques. He is ready to give you fast, efficient service on any insulation job—large or small. Proud of his reputation for integrity in his own community, the J-M Insulation Contractor merits your complete confidence.

Insulation Contract Units . . . Fully aware that no insulation is better than the man who applies it, the J-M Insulation Contractor makes care and skill in the scientific application of Johns-Manville insulations his stock in trade. He maintains a complete crew of

estimators and mechanics trained in J-M application techniques. He is ready to give you fast, efficient service on any insulation job—large or small. Proud of his reputation for integrity in his own community, the J-M Insulation Contractor merits your complete confidence.

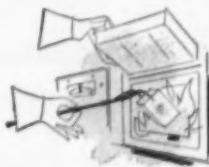
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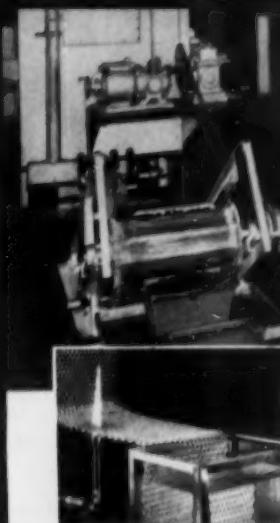


Experienced Management— At headquarters as well as in the field, management of the new insulations division consists of men who, in line with J-M's promotion-from-within policy, are insulation veterans. With a realistic grasp of customers' needs, they are alert to new and better ways to serve you . . . now, and in the future.

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Personals . . .

Marvin J. Udy has received an honorary Doctor of Science degree from Alfred University in recognition of his achievements in the field of electric furnace research. Dr. Udy is an associate and consultant of Stratmat, Ltd., and is connected with Strategic-Udy Metallurgical & Chemical Processes, Ltd.

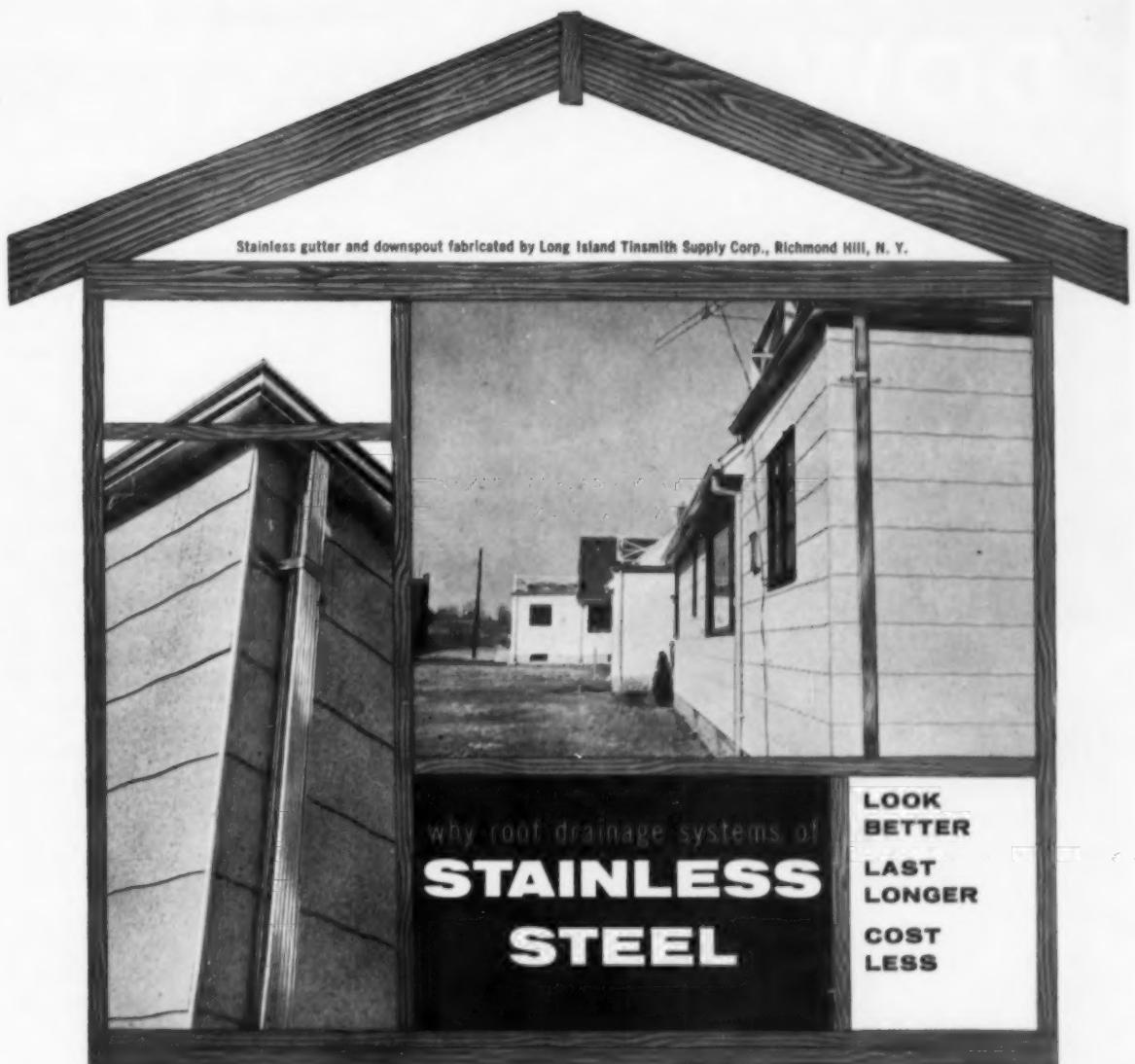
Maurice F. Garwood was awarded the professional degree of metallurgical engineer at the Ohio State University commencement exercises in June in recognition of his engineering ability and accomplishments in the field. A 1933 graduate of Ohio State, Mr. Garwood is chief materials engineer for the Chrysler Corp., Detroit. He joined Chrysler in 1941.

Richard A. Wilkins, vice-president in charge of the research and development department of Revere Copper and Brass Inc., Rome, N. Y., has been elected a Fellow of the Institute of Metals in London, England. The number of Fellows is limited to 12, and Mr. Wilkins is the first nonresident of the United Kingdom to receive this honor.

Paul Ffield has been named an assistant manager of research at Bethlehem Steel Co., Bethlehem, Pa. Mr. Ffield is one of two assistant managers who succeed John S. Marsh, recently promoted to manager of research.

Eraldus P. Scala has become head of the materials section, research and advanced development division, Avco Mfg. Co., Stratford, Conn. For the past eight years, Dr. Scala has been associated with the Chase Brass & Copper Co., Waterbury, Conn., as metallurgist, training director and, since 1953, head of the physical metallurgy group in the research department.

Macon Jordan has been named product manager, toolsteel sales, in the Cincinnati plant area for Solar Steel Corp., Cleveland. Mr. Jordan was formerly associated with Universal-Cyclops Steel Corp. and Firth Sterling, Inc., where he served as Ohio district sales manager.



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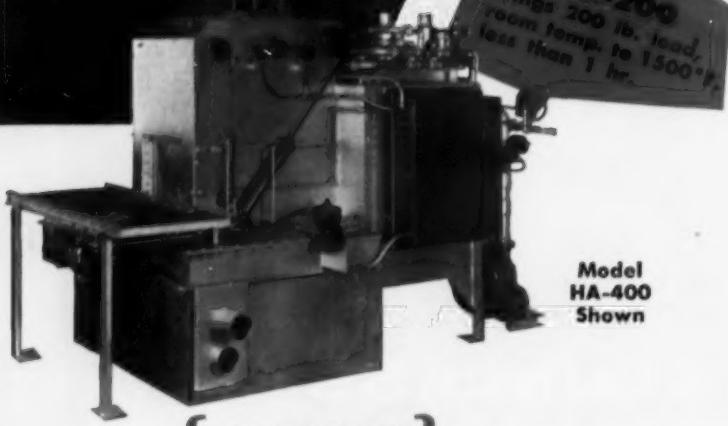
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Personals . . .

Four members of the American Society for Metals received Awards of Merit at the annual meeting of the American Society for Testing Materials held in Atlantic City last summer. W. L. Fink , chief of the physical metallurgy department at the Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa., was honored for his contribution to the fields of metallography and X-ray diffraction. Bruce W. Gonser , assistant director of Battelle Memorial Institute, Columbus, Ohio, and Roland P. Koehring, section engineer for research and development, Moraine Products Div., General Motors Corp., Dayton, Ohio, received awards in recognition of their leadership and support in standardization and research work, Mr. Gonser in the field of nonferrous metals and alloys and Mr. Koehring in powder metallurgy. Vincent T. Malcolm , consultant and advisory engineer, Chapman Valve Mfg. Co., Indian Orchard, Mass., was recognized for his long-time support of many standardization and research projects and for his work on the effects of temperature on metals.

H. M. Clarke is now vice-president of Detroit operations and general manager of the Detroit plant of Bliss & Laughlin, Inc., Harvey, Ill.

John Wallerius has been appointed chief engineer of the Lindberg Industrial Corp., Chicago. Before joining Lindberg, Mr. Wallerius was associated for 25 years with the furnace division of Sunbeam Corp., Chicago, as chief engineer, and more recently with Sigma Metallurgical Co. as president.

John B. Seastone has been appointed director of the technical division, Olin Mathieson Chemical Corp., East Alton, Ill. Mr. Seastone was formerly research and development manager for the metals division of the company. Before joining Olin Mathieson, he was manager of the materials division for Westinghouse Electric Corp., and a recipient of the Westinghouse Award of Merit.

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This Inconel retort, sand seal pan, grid support and lifting frame is one of many intricate Rolock welded fabrications for high-heat operation. It is used for brazing in a hydrogen atmosphere, alternately heated to 2200° F., lifted out of the furnace and cooled.

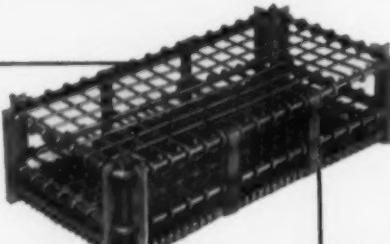
Size: Retort 24" diameter x 46½" long, excluding pipe. Supporting frame 46⅓" diameter x 57½" O.A. Weight: 200 lbs.



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Personals . . .

E. A. Nave has been appointed sales manager, fabricated products, metals division, Olin Mathieson Chemical Corp., East Alton, Ill. Mr. Nave was production manager of the brass strip operation and technical advisor to the vice-president of operations for the company before his new appointment.

D. K. Crampton , director of research and development, Chase Brass & Copper Co., Inc., Waterbury, Conn., presented the fifth Gillett Memorial Lecture on "Structural Chemistry and Metallurgy of Copper" at the annual meeting of the American Society for Testing Materials last summer. This lecture, sponsored jointly by the A.S.T.M. and Battelle Memorial Institute, Columbus, Ohio, commemorates H. W. Gillett, first director of Battelle, and each year covers a subject pertaining to the development, testing, evaluation and application of metals.

G. D. Smelzer has been promoted to district manager of the Hamilton, Ont., branch of the Railways & Power Engineering Corp.

John A. Hincks has joined the metallurgical staff of Battelle Memorial Institute as a project engineer in the metals joining division.

J. E. Williams , formerly vice-president for operations, metals division, Olin Mathieson Chemical Corp., East Alton, Ill., has been appointed vice-president and general manager of the Western Brass Mills Div. Mr. Williams will direct operations at East Alton and also the company's brass mills at New Haven.

A. E. White , consulting engineer, retired director of the Engineering Research Institute and professor of metallurgical engineering at the University of Michigan, Ann Arbor, was presented an honorary membership in the American Society for Testing Materials at the society's annual meeting last summer. Dr. White has been a member of A.S.T.M. since 1914, and was the first national president of the American Society for Metals in 1920.



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Digests of Convention Papers

Fatigue Life of Aircraft Quality Versus Vacuum Melted 4340

Digest of "Relation of Inclusions to the Fatigue Properties of S.A.E. 4340 Steel", by H. N. Cummings, F. B. Stulen and W. C. Schulte. © Preprint No. 23, 1956.

THE FATIGUE strength of many alloy steels is related to the quantity of nonmetallic inclusions. In this paper the fatigue strengths of approximately 1000 smooth R. R. Moore specimens of a single commercial S.A.E. 4340 steel of aircraft quality and about 100 specimens of a single high-purity heat vacuum melted are compared. S-N curves were obtained for both smooth and notched specimens at nominal ultimate tensile strengths at three levels (140,000, 190,000 and 260,000 psi.). From data and a microscopic examination of the surface of the specimens, the location of the fractures, the nature of the fractured surface and the inclusion content were related to the fatigue strength. At the lower stress level most of the failures originated at small inclusions open to the surface. Their size was measured and, since most of them were spheroidal, the "geometric mean diameter" of the exposed cross section was adopted as a size parameter. It was found by statistical analysis that there was a relation between the sizes of the inclusions associated with failures and the life of the specimens. (For specimens where the fractures occurred at a considerable distance from the minimum cross section, the actual fatigue life was adjusted to what it probably would have been if the central inclusions had been at the minimum cross section.)

At higher stress level (190,000 and 260,000 psi.), the relatively simple correlation between size of inclusions and fatigue life was altered. Multiple nuclei of fracture ap-

peared in increasing numbers of specimens. In some, a rather large inclusion appeared in a nucleus at a measurable distance below the surface of the specimens of relatively long life.

Nuclei could be measured and counted (but no inclusions) in the vacuum melted steels tested on the 190,000-psi. strength level, and the number of nuclei increased faster than in the commercial steel. The figure shows that the endurance limit (50% probability) for the two varieties is about the same at 140,000-psi. strength level, even though the vacuum melted steel has twice the number of fracture nuclei (8 versus 4). The authors suggest that the vacuum melted steel may have submicroscopic inclusions or stress raisers of a physical nature.

The authors make the following "predictions":

1. The first microcrack appearing on the surface of the specimen will always be associated with a large inclusion, regardless of the stress level, but the final fracture may not be associated with the first crack.

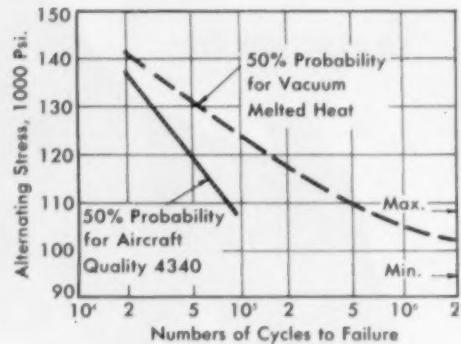
2. The variance of the location of the first microcrack will be independent of the stress level.

3. As is also true of fatigue at high stress levels, the static tensile fracture will be initiated at the location having the largest number of small inclusions in or about one plane.

4. The number of cracks appearing on the surface of a "failed" fatigue specimen away from the fractured surface increases with the stress level. (This could account for the sagging of specimens under high stress.)

5. Material such as vacuum melted steel having numerous, extremely small, inclusions or discontinuities will have a flatter slope of the upper branch of the S-N curve when compared to that of a commercial heat.

6. If all the very small inclusions



S-N curves of S.A.E. 4340, Aircraft Quality Vs. Vacuum Melted, Heat Treated to 190,000-Psi. Tensile and Tested as Rotating Beam

and other microstress raisers could be eliminated from metal, its fatigue life under very high overstresses would be increased by a large amount.

7. Similarly, if only the large inclusions were eliminated (which occurs in steels vacuum melted from pure raw materials), the life for low fatigue overstress would be greatly increased even though fatigue life for high overstress would be improved little if at all.

D. J. CARNEY

Temperability of Steels

Digest of "Temperability of Steels", by L. D. Jaffe and Edward Gordon. © Preprint No. 14, 1956.

A NEW METHOD of calculating the proper tempering temperature for a quenched steel to obtain a specific hardness is described in this paper. It is a much simpler and more rapid system than others which have been used and is reported to be more accurate.

Six charts are used in conjunction with a simple equation to make the necessary calculations. The first three charts are used to read off the contribution of alloying elements and grain size to "composition hardness".

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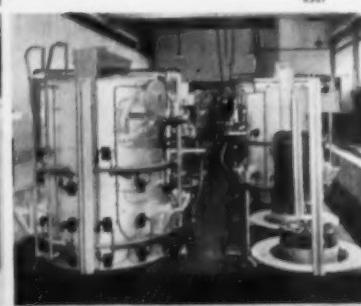
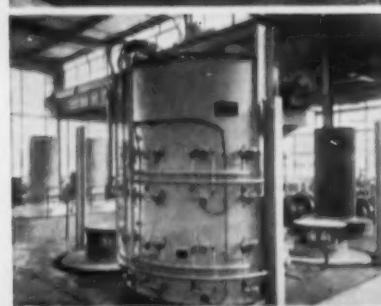
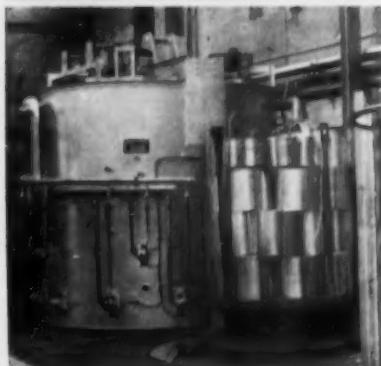
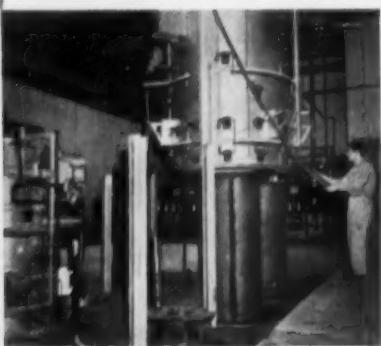
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Temperability . . .

This figure is introduced into the simple equation to allow a first approximation of the tempering temperature and the three succeeding charts are used to refine the first approximation.

The computations are based on statistical analysis of about 5000 hardness measurements of samples from 85 heats of steel. The authors indicate that the empirical relationship developed should be used cautiously for steels whose compositions are much outside the range of alloys studied. Another limitation is the requirement that the structure of the steel before tempering should consist essentially of martensite.

The standard deviation of this method, where applied to the experimental data, is 39° F., which is equivalent to Rockwell C-1.3. The results are slightly more accurate than can be obtained by the methods developed by Crafts and Lamont or Grange and Baughman. The calculations are much simpler and less time-consuming.

W. A. REICH

New Nodular Iron Process

Digest of "New Nodular Iron Process", by Harry K. Ihrig.
© Preprint No. 7, 1956.

MANY ATTEMPTS have been made to modify the graphitic structure of cast irons, and mechanical properties are improved when the graphite is in spheroidal particles rather than in flakes. Cerium and a nickel-magnesium alloy have both been successful additives for producing this "spheroidal" or "nodular" graphite. Sodium is also effective. The magnesium process is most widely used today in the United States. Cerium or misch-metal additives are considerably more expensive.

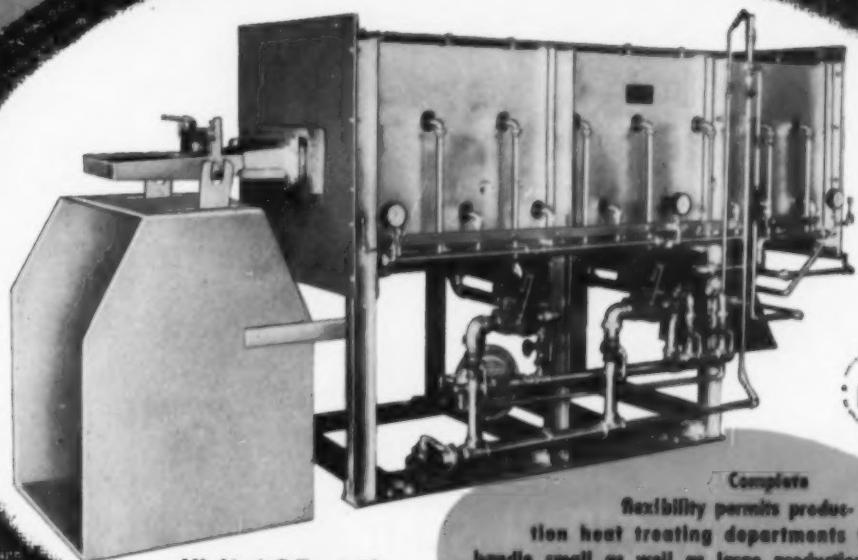
Magnesium is added to molten iron with difficulty because of its high vapor pressure and its explosive reaction with oxygen at molten iron temperatures. The use of dilute alloys with nickel or copper reduces the hazard but is an added cost, and the diluting elements tend to concentrate in the scrap.

This paper describes the use of chlorides (and the other halides) of sodium, magnesium, strontium, lith-

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Patent 2,671,654

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Nodular Iron . . .

ium, rubidium, barium and cerium when combined with calcium silicide (30% calcium) as a reducing agent.

The molten base iron (total carbon 3.81% to 4.34%, silicon 0.63 to 0.68%, phosphorus 0.025 to 0.060%, sulphur 0.023 to 0.039% and manganese 0.10 to 0.15%) was poured into a ladle containing various mixtures of calcium silicide and the above-mentioned halides. After completion of the reaction, the slag is skimmed and the iron cast into molds.

The mechanical properties of the heat poured on magnesium chloride showed the best properties, with a yield point of 47,500 psi., tensile strength of 80,500 psi., and elongation of 13%. The cast with sodium chloride also showed good tensile strength but elongation was 3%.

Because these two were most successful in the experimental heats, a number of commercial heats were made using mixtures of sodium and magnesium chlorides and calcium silicide. Two typical heats are described which had the following additions: 0.4% sodium chloride, 0.8% magnesium chloride and 1.8% calcium silicide. These heats as well as other commercial heats were melted in a basic lined cupola — although other methods which produce low-sulphur irons may also be used.

Chemical analysis of these heats showed that the nodulizing action reduced the total carbon about 80 points, and the sulphur to very low figures (0.01 or less). Manganese and phosphorus were unchanged at 0.50 and 0.050 respectively. Silicon was more than doubled (to 2.90%) and a small amount of magnesium (0.025%) is retained.

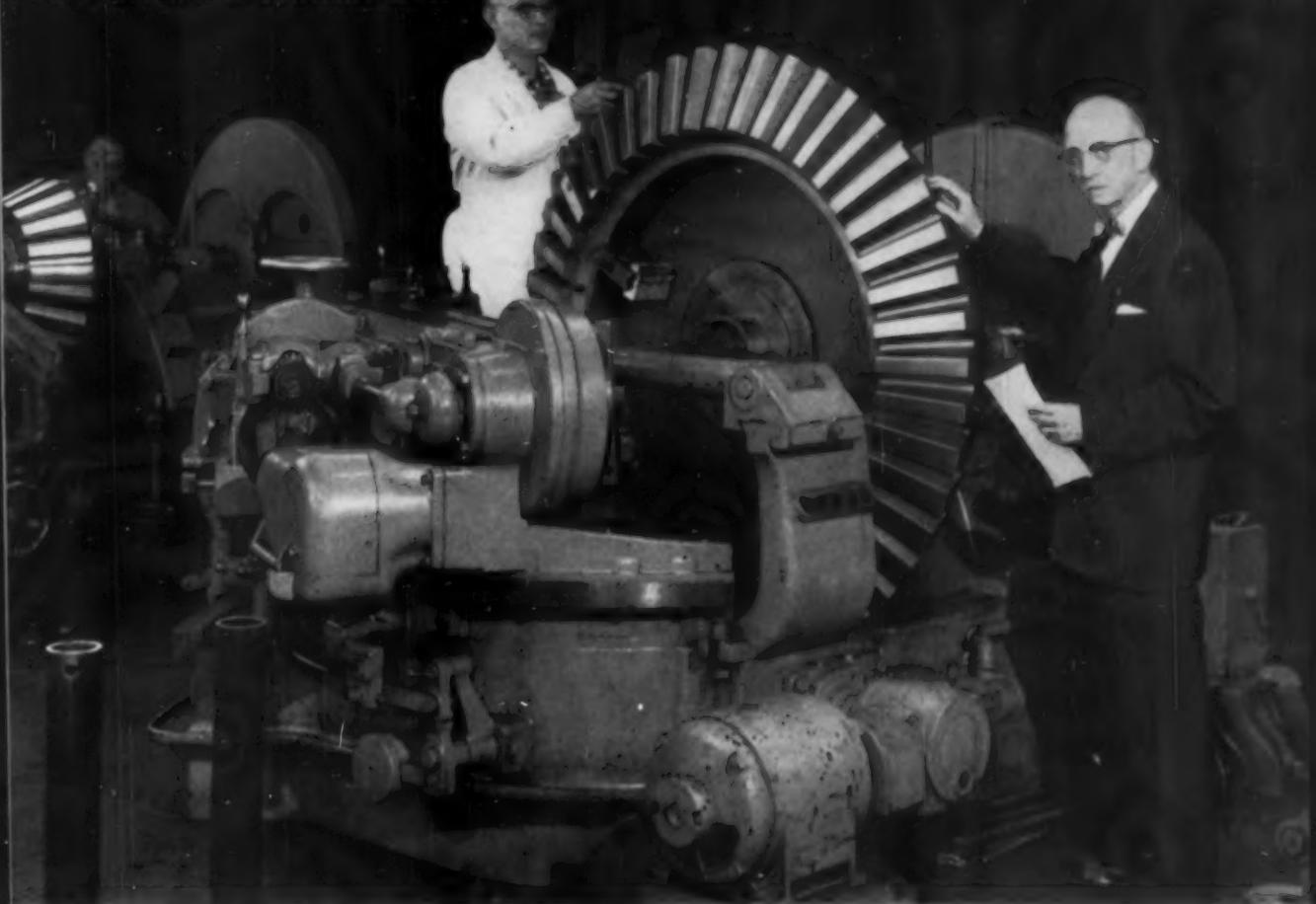
Mechanical properties after nodulizing are as follows: tensile strength 79,500 and 84,400 psi., yield 60,000 and 64,000 psi., elongation in 2 in. 19.5 and 12.5% and Brinell hardness 187 and 197, respectively.

Microstructures of the above irons were a mixture of ferrite, pearlite and nodular or spheroidal graphite.

Approximately 1400 tons of various castings were cast using the above campaign with so much success that a 54-in. basic-lined cupola with a melting rate of 10 tons per hr. has been put into service by Allis-Chalmers Mfg. Co.

PAUL G. NELSON

IT'S BETTER IF IT CONTAINS MOLY



E. B. Smiley, Metallurgist for Illinois Gear & Machine Co., looks over setup of large, heavy duty bevel gear made from molybdenum

alloy steel casting. This gear has been rough turned, rough cut and heat treated to 269 to 302 Brinell before finish cutting.

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**Toughness of Malleable
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Digest of "Notch Ductility of Malleable Irons", by G. A. Sandoz, N. C. Howells, H. F. Bishop and W. S. Pellini. Preprint No. 6, 1956.

THIS STUDY is on malleable iron specimens containing sharp notches. The temperature at which failure occurs without prior plastic deformation ("nil ductility transition") was determined by a drop-weight test. The notch is a cleavage crack produced by laying down some brittle weld material on the surface of the specimens. Explosion tests and Charpy V-notch tests were also made to determine if the same correlations exist in malleable irons as previously observed for other ferrous materials. The effects of chemical composition, microstructure and section size were determined for experimental malleable irons, and the results compared with commercial malleable irons, nodular irons and other ferrous materials.

Phosphorus in the range 0.03 to 0.20% increases the nil ductility transition from -150 to 0° F. while sulphur (0.024 to 0.200%) has little if any effect, especially below -150° F. provided more manganese is present than the amount needed to combine with the sulphur. An increase in section size increases the nil ductility transition in untreated irons, but inoculants which insure a nodular type of graphite eliminate the size effect. Commercial ferritic irons of this kind have a nil ductility transition at about -50° F. in section sizes up to 3 in.

Pearlitic malleable irons appear to be sensitive to the type of heat treatment. Heat treatments to Brinell hardnesses between 160 to 190 have nil ductility transition between 10 and 70° F. Removing any decarburized surface generally raises the transition temperature about 20° F.

When the nil ductility transition temperature is correlated with curves showing the Charpy V-notch energy transition, it appears that brittle fracture without prior plastic deformation occurs. The explosion crack-starter tests show that brittle fractures may be forced to occur at temperatures above the nil ductility transition only when severe deformation occurs. At temperatures approx-

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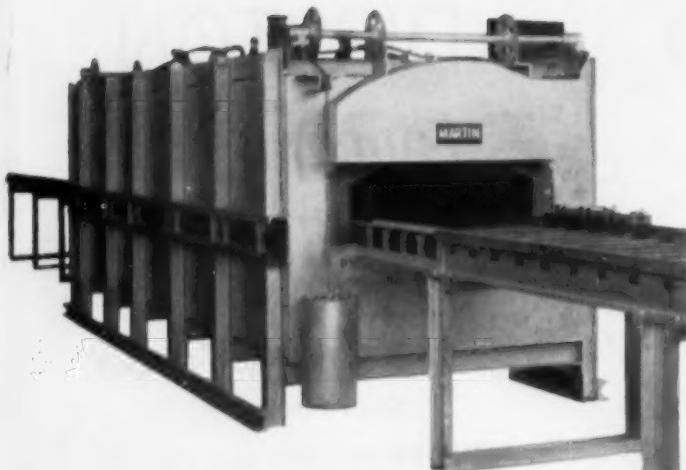
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imately 50° F. above the nil ductility transition temperature, the propagation of brittle fracture becomes so difficult that the sample does not completely fracture.

When compared with other ferrous materials, it is observed that ferritic malleable irons have similar notch ductility values to low-silicon, low-phosphorus, ferritic nodular irons. Pearlitic malleable irons properly inoculated compare favorably with average ferritic nodular irons, rolled semikilled, and fully killed mild steel plate.

G. J. SALVAGGIO

Air Contamination of Titanium Alloys

Digest of "A Study of the Air Contamination of Three Titanium Alloys", by J. E. Reynolds, H. R. Ogden and R. I. Jaffee. Preprint No. 11, 1956.

THE UPPER temperature limits for forging and rolling titanium alloys have been restricted because of the inward diffusion of oxygen and nitrogen when billets are heated in air. The hot working range has usually been determined by trial and error and this study was designed to develop a more precise method of predicting safe temperature limits.

Cylindrical specimens were heated in a static air atmosphere of an electric muffle furnace for various periods of time up to 24 hr. at temperatures up to 2100° F. To determine the uncontaminated base-hardness levels, control specimens were heated in argon at each temperature. Four microhardness traverses from the surface extending inward were made on each specimen to obtain a hardness penetration curve.

Diffusion coefficients associated with the contamination process were calculated by applying the Van Ostrand-Dewey diffusion analysis to hardness penetration curves. Parametric equations were derived which express the depth of contamination as a function of time, temperature and the activation energy associated with the contamination process. Nomographs summarizing the findings are presented for three alloys.

G. A. FRITZLEN

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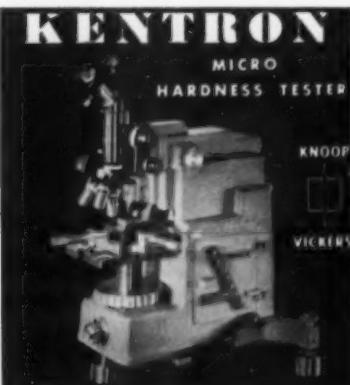
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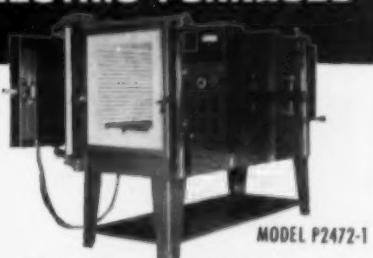
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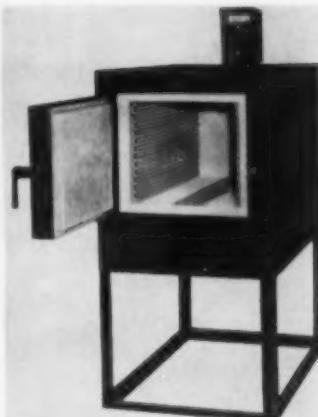
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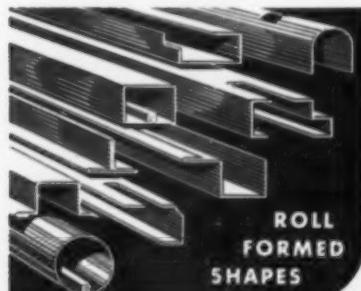
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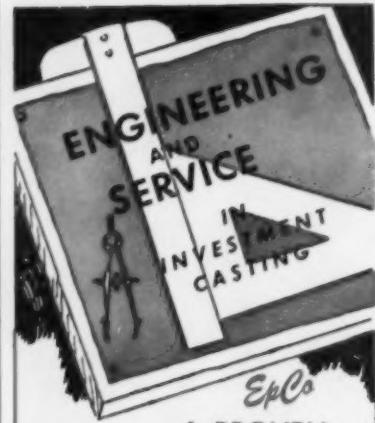
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Transformation on Continuous Cooling

Digest of "On the Cooling Transformations in Some 0.40% Carbon Constructional Alloy Steels", by D. J. Blickwede and R. C. Hess. *Preprint No. 17, 1956.*

IN STEEL PRACTICE, most hardening is done by quenching as rapidly as possible from the austenitizing temperature. Isothermal treatments — so-called — quench only part way down to room temperature, and a vast amount of work has been done on the microstructure and properties of steels so treated. However, few have followed the lead set in 1944 by Liedholm and Blickwede in studying the transformation of aircraft and propeller steels during continuous cooling at rates possible in various commercial quenching solutions and dies — which as remarked above, is the ordinary method of heat treatment. To construct such a cooling transformation diagram (or C.T. diagram), a series of bars may be end-quenched for various periods of time and then quenched in brine, which "freezes in" the structures existing along the bar at the time of quench. Metallographic and hardness surveys then give the data from which C.T. diagrams are constructed.

In this paper C.T. diagrams were determined on A.I.S.I. 4340, 9840, 86 B 40, 4140 and 5140. Except for the 4140 (which was a 4-in. round), all steels were $1\frac{1}{4}$ to $1\frac{1}{2}$ -in. rounds. Liedholm's method was expanded to include the measurement of transformation by lineal analysis and determination of M_s temperatures. The diagrams therefore show the amounts of transformation at any time — information not usually contained in previously published diagrams.

The following pertinent observations can be made:

1. If the criterion is the beginning of transformation, hardenability is controlled by the bainite reaction. However, if the criterion is 99% transformation (99% martensite), the bainite reaction controls hardenability of 4340 and 9840 whereas pro-euctectoid ferrite controls hardenability of 86 B 40, 4140 and 5140.

2. If the criterion is 50% transformation, the formation of bainite and pro-euctectoid ferrite controls hardenability of 86 B 40 and 4140, but

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Continuous Cooling . . .

the pearlite reaction combines with them for 5140.

3. The portion of the end-quenched bar which was below the M_s temperature before the final quench in brine contains a tempered, dark-etching martensite whereas the portion which was above M_s contains untempered, light-etching martensite. This led to a method for determining M_s , and the values

checked within 15 to 35° F. of calculated values (except on the 4140 specimen which had not been completely austenitized). Hardness values at the $\frac{1}{4}$ -in. position on the 4340 steel decreased as much as three points on the Rockwell C scale because of the simultaneous formation and tempering of martensite.

4. The M_s temperatures of all five steels examined were lowered by slow cooling. The magnitude of this effect was not related to prior bainite formation. With 4340 and 9840 it

seemed to depend only on the cooling rate. With 4140 and 5140 it appeared to result from carbon enrichment of untransformed austenite during the preceding formation of pro-eutectoid ferrite. The presence of retained austenite in slow-cooled 4140 was confirmed when the hardness increased three to five points on the Rockwell C scale after refrigerating to -321° F. Because less pro-eutectoid ferrite was formed, less carbon was available to enrich the austenite in 5140, and it did not harden when refrigerated.

5. In all the steels examined an acicular type of ferrite termed paraferrite formed prior to bainite at cooling rates less than critical. This was readily observed in 4340 and 9840, but it was obscured by overlapping pro-eutectoid ferrite in 86 B 40, 5140 and 4140.

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Digest of "Effect of Sigma Phase on Cobalt-Chromium-Molybdenum Base Alloys", by Ronald Silverman, William Arbiter and Frank Hodi. Preprint No. 31, 1956.

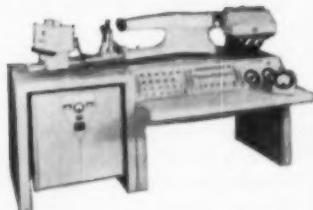
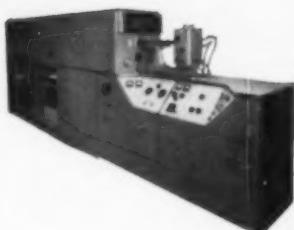
THE BRITTLE intermetallic sigma phase which occurs in various alloy systems is a constant challenge to metallurgists. Here it was studied in the "Vitallium" or "Stellite 21" family to see if increasing amounts would stiffen this alloy system at 1800° F. and to determine associated properties at that temperature.

From the basic alloy with 28% Cr, 67% Co, and 6% Mo, which is substantially sigma-free, five alloys ranging up to 43% Cr, 42% Co and 15% Mo were made, attaining about 15, 28, 39, 63, and 76% of the sigma phase. (Incidental elements were about 0.40% C, from 0.31 to 0.70% N, and about 2% each of nickel and iron.)

Density decreased from 8.30 g. per cc. with 15% sigma to 8.17 with 76% sigma, while resistivity increased slightly (101 to 107 microhm-cm.). Hardness increased from about Rockwell A-60 to A-82, while impact resistance fell sharply. These trends were not much influenced by thermal history.

Five heat treatments were imposed: (a) as cast, (b) solution

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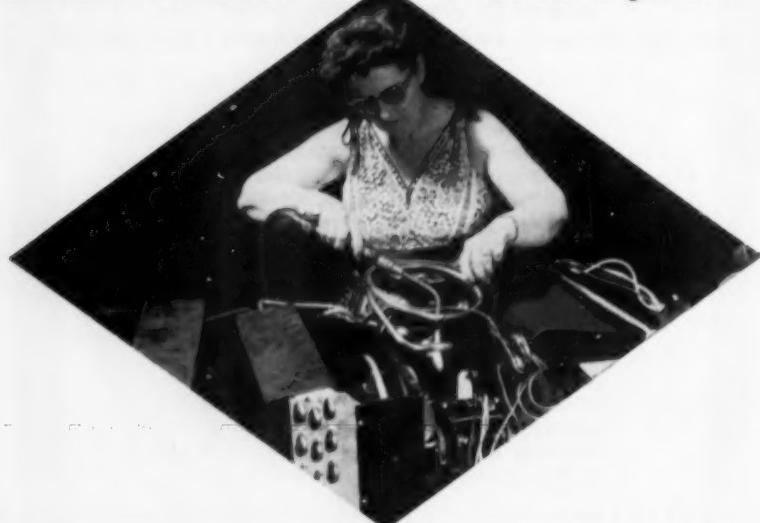
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Sigma Phase . . .

treated at 1250° C. (2280° F.) for 0.5 hr., (c) 1250° C. for 24 hr., (d) aging at 730° C. (1345° F.) for 50 hr. after treatment (b), and (e) aging 50 hr. at 730° C. without previous solution treatments. All heat treatments ended with air cooling. The 76% sigma alloy was softened by solution treatment, but hardening occurred with 63% sigma. The 39% sigma alloy was erratic; alloys with 28 and 15% sigma were softened by the high-temperature treatments and hardened by the low-temperature.

Energy absorbed in the N.A.C.A. drop impact test ranged from 33 in-lb. down to 0.5. Aging treatments caused precipitates along crystallographic planes and markedly decreased impact resistance.

Many interesting microstructures appeared. Besides the basic alpha solid solution and sigma, the $M_{23}C_6$, Cr_7C_3 , CrN, and beta phases were probably present. Lamellar, massive, acicular, and grain-boundary habits were noted. The lamellae were suspected of being a ternary or binary eutectoid ($Cr_{23}C_6 + Co$ -rich solid solution); they are most prevalent in the high-sigma alloys and were substantially eliminated by solution heat treatment. Oriented precipitation patterns followed the aging during treatment (d); they are grid-like and appear to be related to sigma content.

Stress-rupture tests at 1800° F. and 10,000 psi. appeared to give quite significant data. The maxima were 28 hr. (25% reduction of area) for 15% sigma, as cast; and 34 hr. (10.3% reduction of area) for 28% sigma after aging treatment (c). With 39% sigma or more the longest life was 7 hr. Ductility was decreased by aging, but creep resistance was not enhanced. Since the Vitallium or Stellite 21 (sigma-free) has an expectancy of about 50 hr., sigma seems detrimental to the useful high-temperature strength as well as to toughness. (The authors had trouble confirming this figure from one commercial heat. However, the specimens were badly twisted in testing and the discrepancy was assigned to either faulty material or faulty equipment.)

Therefore better hot strength cannot be secured in this system through sigma formation.

H. S. Avery



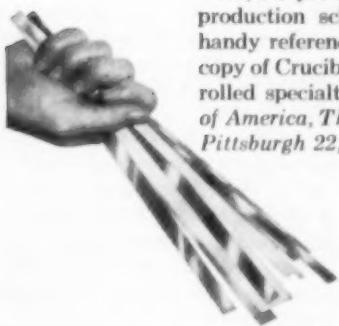
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Notch Toughness of Ingot Iron

Digest of "The Effect of Sub-Boundaries and Carbide Distribution on the Notch Toughness of an Ingot Iron", by J. C. Danko and R. D. Stout. © Preprint No. 5, 1956.

THIS PAPER studies the effect of subboundaries and carbide distribution on the notch toughness of a commercial ingot iron. By changing the heat treatment, the ferrite grain size, the subgrain size and the carbide distribution were varied prior to testing. Annealing temperatures ranged between 1650 and 2200° F. to vary the primary ferrite grain size; cooling rates (furnace, air, or water quenching) gave differences in subgrain size. Carbide distribution was changed by solution treatment at 1300° F., furnace cooling or quenching, and aging at 400° F.

Annealed samples had a transition temperature about 100° F. higher than the quenched and aged ones — provided average grain size of the primary ferrite is the same. With a constant subgrain size in the ferrite, an increase in the size of the primary ferrite by one grain size number raises the Charpy V-notch transition temperature approximately 20° F.

The 100° F. difference noted at the beginning of the last paragraph is a reflection of a different carbide distribution. In the annealed specimens, discontinuous carbide networks exist in the ferrite grain boundaries and fine discrete carbide particles in the subboundaries. On the other hand, the solution-treated and aged material contained carbides throughout the matrix and subboundaries, the former in the form of platelets. Difference in the notch toughness after the two heat treatments is attributable to this carbide distribution and segregation at the subboundaries.

Subgrain size is independent of austenitizing temperature, but decreases with faster cooling rates. After solution treatment and aging, the pre-annealed ingot iron had a transition temperature 80° F. lower than a prequenched sample of the same primary grain size. In samples furnace cooled after reheating to 1300° F., the difference was 30° F.

Other facts discovered in this investigation include the finding that

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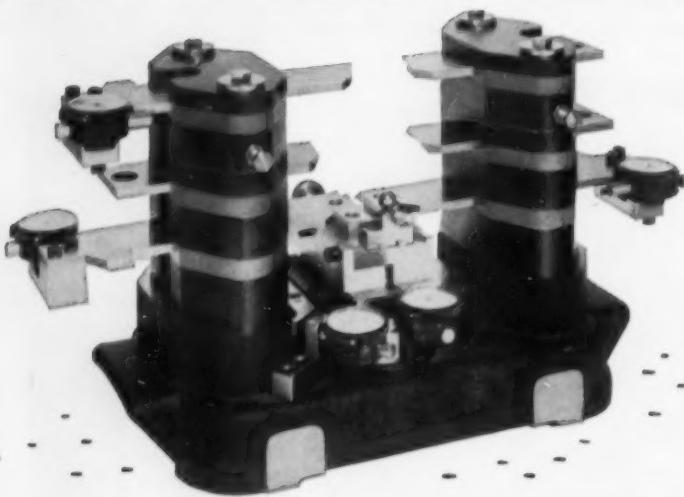
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Ingot Iron . . .

in the normalized condition (air cooled) the ferrite and subgrain size was coarser than after water quenching. After solution and aging, the prenormalized iron had a transition temperature 35° F. (17° C.) lower than the quenched, and 45° F. (25° C.) higher than the annealed iron.

In the furnace cooled condition, the quenched iron embrittles at a lower temperature than the normalized iron. If a correction is made for the difference in ferrite grain size, the normalized iron should have a transition temperature falling between that of the annealed and the quenched iron. Thus, the effect of subboundaries is to raise the transition temperature appreciably in solution treated and aged ingot iron but the effect is decreased in the furnace cooled condition.

In summary, low impact transition temperatures in ingot iron are favored by a fine ferrite grain size, coarse subgrain size, and by a reduction of grain boundary and sub-boundary carbides by the proper heat treatment.

G. J. SALVAGGIO

Deformation in Iron Crystals

Digest of "Slip, Twinning and Fracture in Single Crystals of Iron", by J. J. Cox, G. T. Horne, and R. F. Mehl. *Preprint No. 1, 1956.*

THIS PAPER gives data on the slip, twinning and fracture of single crystals of decarburized mild steel at temperatures from 390° to -320° F. The original material consisted of a silicon killed, hot rolled S.A.E. 1008 steel, decarburized and then strain-annealed to large single crystals. Each crystal was properly oriented in a goniometer before straining 4%. Laue photographs were taken before and after deformation. The orientation and optical measurement of slip traces were plotted on a standard (001) projection.

To study slip in this range of temperature, the angle between the (101) and the maximum resolved shear stress plane containing the slip directions, and the angle between the (101) and the position of the

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Iron Crystals . . .

integrated glide ellipse was measured. (The latter is that plane defined by the average slope of the wavy slip lines observed on the circumference of the crystal.) This integrated glide ellipse occupied various positions in the <111> zone, deviations from the planes (110), (112) and (123) being real. The distribution of the glide ellipse along

the <111> was markedly affected by temperature; lower temperature increased the shearing strengths near (112) more than (110), thus favoring (110) slip regardless of distribution of the applied stress.

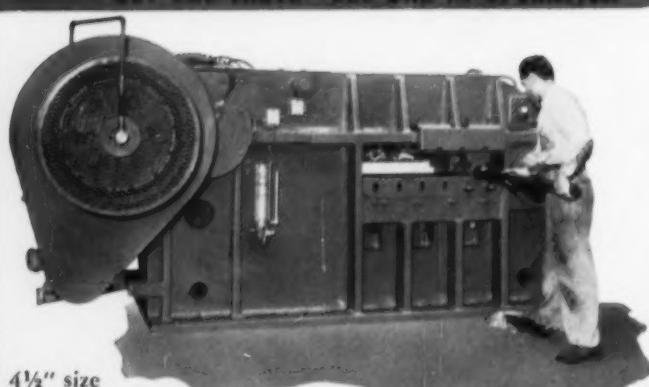
The authors conclude that the critical shear stress law is a valid criterion for the initiation of slip. The stress remains about constant from +32° to +392° F., but increases rapidly as the metal is cooled from +32° to -321° F.

Twins were studied at -321° F. The critical resolved shear stress for twinning was calculated from the load at which an initial burst of twins appeared, accompanied by a loud report. A mean value of 14,100 psi. was found for unstrained crystals, and 20,800 psi. for crystals pre-strained at 70° F. The higher values for the latter indicated that high-temperature slip may inhibit twinning at low temperatures. The initial twin plane was always the one predicted by the critical shear stress theory, but the direction of strain in tension or compression must also be considered. Twinning always accompanies the fracture process and occurs adjacent to the fracture surfaces.

Fractographic examination indicated that brittle fracture is a combination of shear and parting, the proportion of shear being increased by increased angle between the (001) pole and tensile axis, and by prestraining.

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Tougher Iron-Aluminum Alloys

Digest of "The Mechanical Properties of Iron-Aluminum Alloys", by W. Justusson, V. F. Zackay and E. R. Morgan. Preprint No. 36, 1956.

IRON-ALUMINUM alloys have unique electrical, magnetic and refractory properties, but their commercial development has been retarded by their apparent room temperature brittleness. Melting and casting practice, hot working, heat treatment and the effect of alloying elements were therefore examined.

Alloys were made in an induction furnace under vacuum from electrolytic iron. Heats were deoxidized with carbon, held 10 min. under a vacuum of one micron or less, and high-purity aluminum added. All the heats were cast into steel molds at 2900° F. or less to maintain a fine grain size. After slow cooling and re-heating to 1800° F., they were hot rolled to 1/8-in. rounds, often finishing below 1000° F.

A series of ternary alloys containing 0.5% titanium was also made. The titanium was to form a stable carbide with any excess carbon from the deoxidation reaction, and so eliminate any embrittling complex

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We should like to have been represented in the ASM Show at Cleveland with an exhibit of MARVEL Metal Cutting Hack Saws and Band Saws, and would have enjoyed the opportunity of meeting and talking with you. There is much we could have shown and told you that would interest, and perhaps, startle you.

For one thing, we have planned an unusual demonstration which is scheduled to coincide with the completion of the MARVEL plant expansion program sometime during the Fall. By that time, we will have *doubled* our manufacturing space to meet the increasing demand for MARVEL Saws.

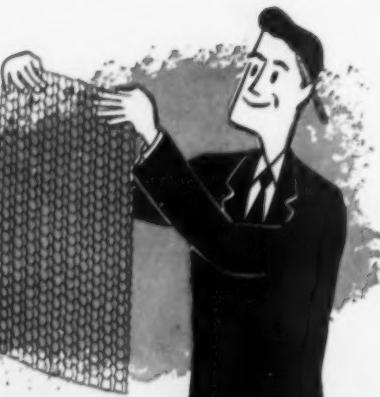
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Fe-Al Alloys . . .

carbides of the iron-aluminum-carbon system.

Prior to testing, the samples were given a recrystallization anneal of 1 hr. at 1400° F., followed either by furnace cooling or water quenching. The presence or absence of a superlattice of the iron-aluminum system was then determined by electrical resistance measurements.

Room-temperature tensile tests show an increase in yield and tensile strength with increasing aluminum in the binary alloys up to about 15 to 16%, whereafter a rapid fall in strength is observed. The maximum in yield and tensile strengths occurs close to the stoichiometric composition of the Fe₃Al superlattice. A decrease in ductility with aluminum content up to 10% was noted for samples either slowly cooled or quenched. At higher aluminum levels the furnace cooled alloys lost ductility more rapidly — probably because of the superlattice remaining after this heat treatment.

The ternary iron-aluminum-titanium alloys are somewhat different. When yield strength is plotted against aluminum content, the curve for the quenched alloys has a flat plateau rather than a sharp maximum. Tensile strength sharply drops at about 14% aluminum in the quenched alloys and at about 12% in the furnace cooled ones. A considerable difference is noted in ductility after the two heat treatments: The quenched alloys have high ductility up to 10% aluminum and a little higher aluminum makes them brittle. The furnace cooled alloys show a gradual decrease in elongation from a value of 40% for 8% aluminum to zero at 12% aluminum.

In alloys containing 10% aluminum or more, ductility may be improved by quenching from above 950° F. — the critical ordering temperature for the Fe₃Al superlattice. Better ductility also follows quenching in oil rather than water, which minimizes quenching stresses.

It would appear, therefore, that the difficulties ordinarily encountered in processing iron-aluminum alloys can be lessened by controlling the interstitial elements oxygen and carbon, control of grain size, and heat treatment schedule.

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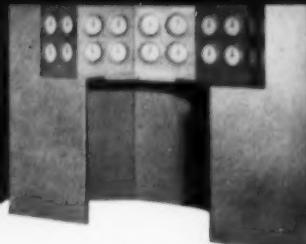
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SPECTROGRAPHIC EQUIPMENT



1.



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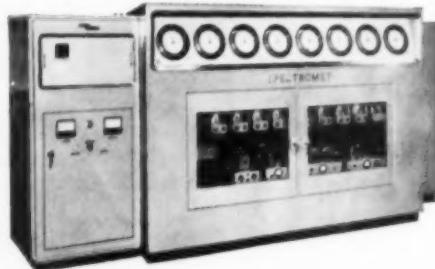
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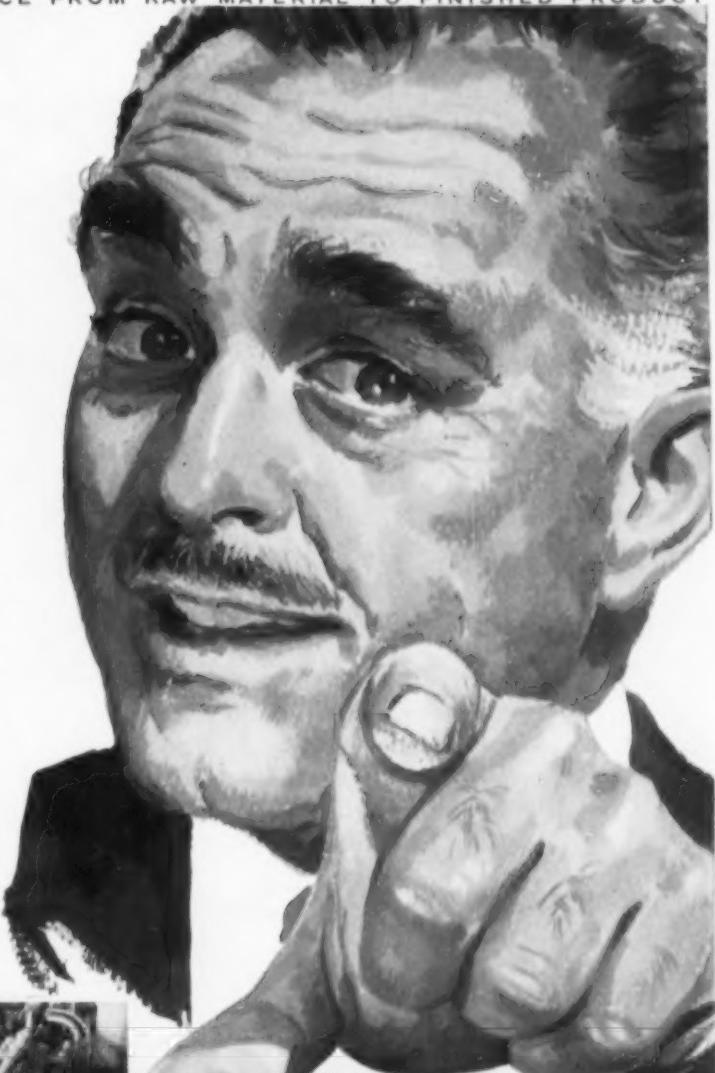
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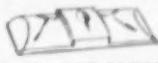
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Advantages of Alpha Versus Beta Titanium at High Temperatures

Digest of "Relative High-Temperature Properties of the Hexagonal Close-Packed and Body-Centered-Cubic Structures in Iodide Titanium", by John Lunsford and Nicholas J. Grant. © Preprint No. 9, 1956.

PHYSICAL PROPERTIES of titanium indicate that it may be a very satisfactory base for high-temperature alloys. However, since it undergoes a phase change at 1620° F. one should know which phase is more suitable. Hence this study of the two phases, their high-temperature behavior, fracture, and testing techniques.

Arc-melted iodide titanium was furnished by the National Research Corp. in 8-lb. ingots. These were forged at 1800° F. to 1-in. square bars, swaged to 5/16-in. rounds, and annealed 2 hr. at 1600° F. in evacuated Vycor capsules. Specimens 0.160 in. diameter and 1-in. gage length were subjected to creep-rupture tests at temperatures between 1000° F. and 1990° F.

The alpha phase (hexagonal) possessed much greater strength and creep resistance than beta (cubic) but the latter had better ductility, indicating that it would provide the better high-temperature matrix.

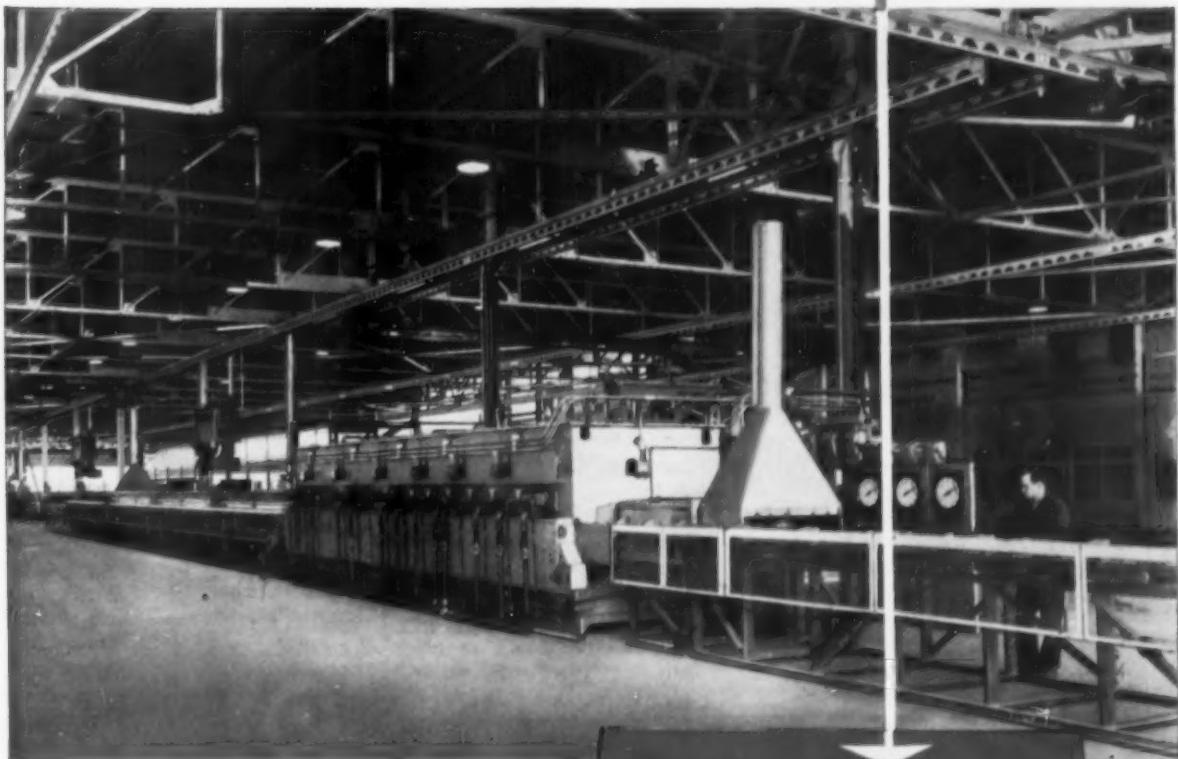
During creep-rupture tests recrystallization occurred after 1 hr. at 1000° F. In contrast to this, a statically tested specimen, cold worked to 90% reduction in area, required 2 hr. at 1200° F. Recrystallization in the creep specimen occurred around a lenticular nucleus which remained distinct from the new matrix. Since this nucleus was unstable at 1000° F. and was not found in the annealed condition, it was assumed to be a deformation product — namely, the 1012 twin.

Another finding was that heating titanium softened it at first (due to a tempering effect) but if heating were continued, hardness would subsequently increase. This was attributed to oxidation alloying. It strengthened the material to such an extent that creep appeared to have ceased completely between 1400 and 1600° F. Above 1600° F. the alloying was so rapid that the specimens had to be

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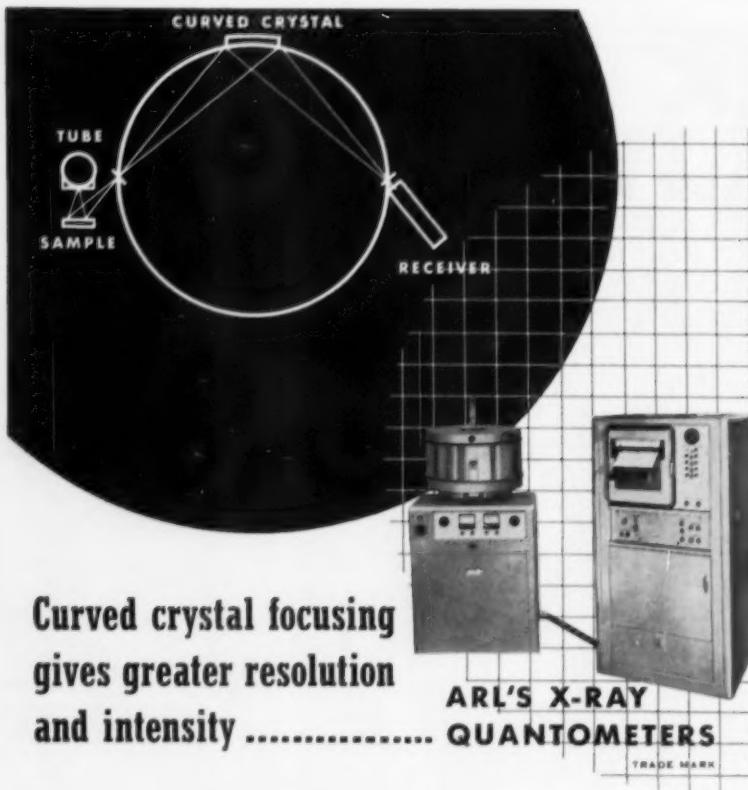
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Titanium . . .

placed in a superheated furnace for a short time in order to minimize the alloying effect. This preheat time was too short to transform all the alpha in the specimens tested at 1650° F., and therefore gave erratic results since transformation was taking place during the test. This was verified by metallography. It was later found that 0.1 hr. at 1650° F. was required for complete transformation, and no untransformed alpha was found at higher temperatures.

BERNARD TROCK

Hot Hardness of Iron and Steel of Super Purity

Digest of "The Temperature Dependence of the Hardness of 'Pure' Iron and Various Ferritic Steels", by F. Garofalo, G. V. Smith and D. C. Marsden. © Preprint No. 15, 1956.

HARDNESS of steels, as it varies with temperature, is related to the corresponding tensile strengths and creep and rupture strengths. Also, hot hardness is known to be sensitive to such phenomena as strain aging, recovery and recrystallization, and phase changes. While the hardness of pure metals (expressed in kg. per sq. mm.) follows an experimental relationship where H is hardness, T is absolute temperature and A and B constants, "pure" iron and commercial steels at elevated temperatures have been meagerly investigated in this respect. This deficiency has now been removed by the paper under review. It presents data on the change in hardness with temperature up to 1200° F. of "pure" iron, low-carbon commercial steels, and chromium steels from 1 to 27% chromium. Some of the latter contained molybdenum, silicon and titanium.

The experimental results for most "pure" metals show that hardness continually decreases with increasing temperature. By plotting log hardness against absolute temperature, straight lines result. This was not found in the present report, and the deviation was associated with a strain aging reaction caused by the small amounts of nitrogen and carbon which the metal contained. This

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Hot Hardness . . .

was true for "pure" iron, low-carbon commercial steels, 1% Cr steel with 0.5% Mo, and the 17% and 27% Cr commercial steels. The curves for these materials exhibited hardness peaks at varying temperatures which were associated with strain aging reactions. On the other hand, the 8% Cr, 8% Cr-Mo and the 12% Cr steels had *constant* hardness over a 200° F. temperature range; this was also traced to strain aging.

Purification of a low-carbon steel in wet hydrogen and suitable heat treatment of the 5%, 8% and 17% Cr steels containing titanium or silicon,

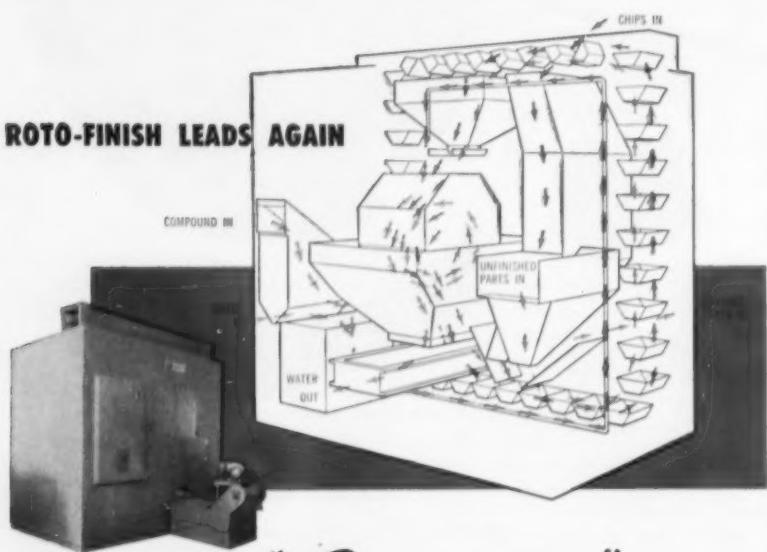
eliminated these anomalies; thereupon the hardness-temperature curves are similar to those of typical nonferrous metals in the pure state.

Some tests were made on samples prestrained 5% in tension at 80° F. and aged 1 hr. at 400 or 600° F. When tested in tension at 80° F., the 1% Cr steel with 0.5% Mo, and the 17% and 27% Cr steels had stress-strain curves showing discontinuous yielding and a measurable increase in flow stress.

A two-step hot hardness test also verified the assumption that steels showing a hardness peak or a constant hardness over a temperature range are susceptible to strain aging.

D. J. CARNEY

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Axial Fatigue and Stress-Rupture in Alpha-Beta Brass

Digest of "Effect of Dispersion of Alpha Phase on the High Temperature Fatigue Properties of Alpha-Beta Brass", by J. E. Breen and Joseph R. Lane. Preprint, No. 39, 1956.

MANY PUBLICATIONS deal with the effects of dispersion of one phase in a multiphase alloy on properties at room temperature, and on creep and stress-rupture. In this paper high-temperature fatigue and stress-rupture were studied.

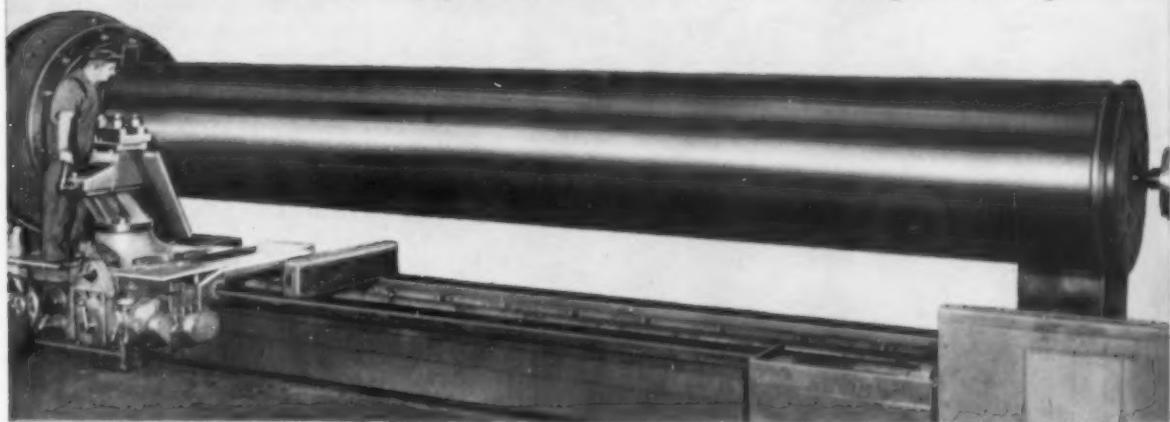
Sections $\frac{1}{2}$ in. round by 3 in. long of alpha-beta brass (60.15% Cu, 0.70% Sn, 0.10% max. Pb) were quenched in water from 1520° F. to produce an all-beta structure supersaturated with alpha, and then reheated or aged at 500 to 1300° F. to obtain a wide variation in the dispersion of alpha. After this last heating, half of the specimens were air cooled; the remainder were furnace cooled. The mean free path between alpha grains in the beta matrix was used as a measure of dispersion. Its logarithm was determined and found to be a straight-line function of the aging temperature.

Fatigue tests were made with specimens at 500, 600 or 700° F. in a Sonntag axial loading machine. The mean load was maintained constant during the test, and the dynamic loading was about 37.5% of the static or mean load. The specimens gradually elongated during the test; this elongation was measured and is called "tensile fatigue creep". Stress-rupture tests were run at the same temperatures and equivalent mean loads. Representative tests are shown below:

TEMPERATURE	STRESS, PSI.
Tensile fatigue	
700 °F.	3000 ± 1100
600	6000 ± 2250
500	11,000 ± 4125
Stress-rupture	
700 °F.	3000
600	6000
500	11,000

1. Tensile fatigue creep rates decreased continuously with decrease in mean free path between alpha grains at all temperatures. In stress-rupture this was true only at 500°;

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Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.

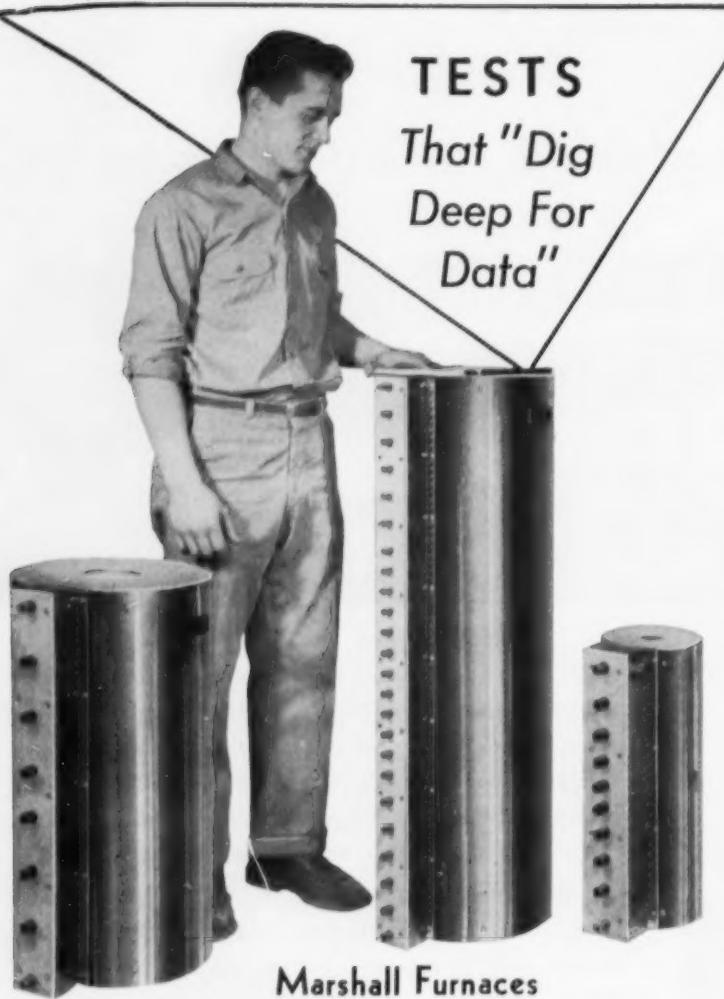
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Tensile Test type Marshall Furnace is shown at right. Brackets can be furnished for attaching furnace to test machines.



FURNACES -- CONTROL PANELS

Fatigue of Brass . . .

at higher temperatures an intermediate dispersion had the highest creep rate.

2. In both tensile fatigue and stress-rupture at 500° F. ductility decreases continuously with decrease in mean free path between alpha grains. At 600 and 700° F. the ductility is at a maximum with intermediate dispersion. Ductility is generally greater in tensile fatigue than in stress-rupture tests.

3. Specimen life is not simply related to dispersion because it depends on creep rate and ductility.

4. At 500° F. the scatter in the data was greater than at higher temperatures.

5. The mode of fracture is not dependent on the dispersion of phases in the microstructure. In tensile fatigue it changes from transgranular to intergranular in the range between 500 and 700° F. All stress-rupture fractures were intergranular.

PAUL G. NELSON

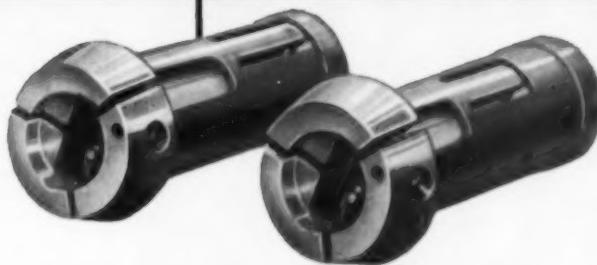
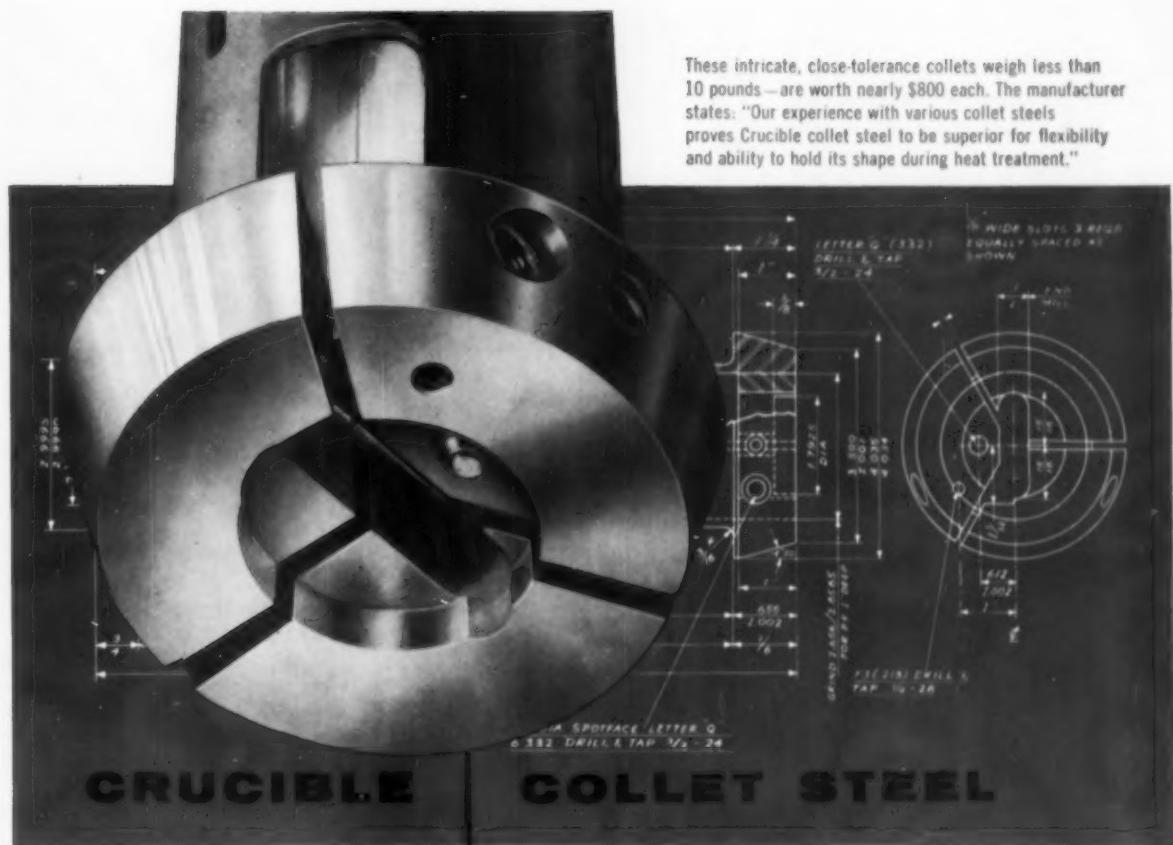
New Dynamic Test

Digest of "Dynamic Bi-Axial Stress-Strain Characteristics of Aluminum and Mild Steel", by George Girard and Ralph Papirno. (Preprint No. 2, 1956.)

THIS PAPER uses a rather unusual approach which may become a tool for evaluating materials in the future.

An impact tube (comprising three pressure chambers, a rupture disk and a specimen) constitutes the major portion of the test assembly. The specimen is a 6-in. disk of thin sheet, in the range of 5 to 15 mils. This is mounted between two of the pressure chambers and both are evacuated. Attached to one of the chambers, and separated by a rupture diaphragm, is a third chamber in which any desired pressure can be pumped. By rupturing the seal, an instantaneous pressure differential is applied to the sheet under test, causing it to bulge and yield under an essentially constant load, continuously applied.

An attached oscilloscope simultaneously traces the timing wave, the time cycle during which the load is applied, stress curves and strain magnitudes (the latter measured



for minimum distortion after heat treatment

These collets are used in machining the anchoring end of jet engine turbine blades, while locating the part from reference points on the airfoil section of the blade. It's a job that demands a steel which will not distort during heat treatment. The collet head is heated to Rockwell 58-60 C—the body tempered to 35-38 C.

The steel used is a special Crucible non-warping alloy collet grade. The collet manufacturer, Balas Collet Mfg. Co., Cleveland, Ohio, reports: *The extreme accuracy built into these collets while they are still in the soft state shows less than .0005" dis-*

tortion on any dimension after heat treatment.

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b—welding operations by which reducing cones and shafts (both statically cast of the same alloy) were welded to the centrifugally cast rolls

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Our new 16-page general Bulletin — 3354-G — gives complete details. Would you like a copy? When writing or calling would you mind telling us the general nature of your high alloy casting requirements? Better yet, if you have specific requirements on which we could help, let us have the details.

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Dynamic Test . . .

directly by electric strain gages).

A theoretical analysis shows how to determine stresses and strains in a two-dimensional field shaped like a spheroidal ellipse. Data and theory also compare the results of dynamic and static tests, there being essentially no difference in the dome shape or stress pattern. With thin membranes the third stress dimension may be ignored.

Data on iron and aluminum samples are compared with uniaxial values such as those from tensile impact and short-time tensile tests. Significant observations include the following:

1. In both metals tested, marked increases in ultimate tensile strength resulted from short impact loadings — on the order of microseconds.

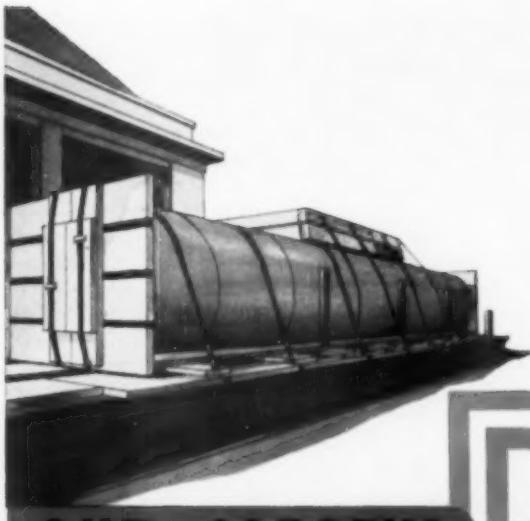
2. Upper and lower yield points were readily discernible in iron. The upper yield point, measured as 50,000 psi. under static loading, increases to 90,000 psi. during loading at a rate of 10^7 psi. per sec.

3. Iron deforms under dynamic loading in a completely elastic manner until the upper yield point is reached. At this point Lüders lines form, and there is a sharp decrease in the central radius of curvature of the diaphragm. Equilibrium between the applied stress and strain rate requires more than 35 milliseconds after maximum load is applied.

4. Catastrophic failures in steel disks sometimes occurred at stresses much lower than would be predicted by uniaxial test data; the mechanism includes formation of Lüders lines and subsequent thinning to the point of fracture. In general, Lüders lines are oriented parallel to the rolling direction. To the authors, some of the catastrophic failures suggest the brittle failures which have occurred in rigid plate structures used by industry.

These preliminary results indicate that the biaxial stress evaluation test may be more reliable for screening materials for complex structures made of sheet and plate than the conventional tensile testing. This important testing device seems worthy of careful evaluation by everyone concerned with dynamic stresses in equipment components.

J. L. WYATT



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Effect of Bainite on Strength

Digest of "The Influence of Bainite on Mechanical Properties", by R. F. Hehemann, V. Luhman and A. R. Troiano. © Preprint No. 16, 1956.

WHEN 4340 steel is heat treated to high strength levels, the presence of high-temperature bainite lowers the yield strength, ductility and impact energy. The reduction of

these properties increases as the amount of the bainite increases. However, as the temperature of formation of the bainite is lowered, reduction of the mechanical properties becomes less severe until at reaction temperatures near the M_s , the ductility and toughness of the mixed microstructure are equivalent or slightly superior to the quenched and tempered microstructures.

The detrimental effect of high-temperature soft bainite on the mechanical properties is believed to be

associated primarily with the hardness differential between bainite and tempered martensite. The same loss in ductility is observed with mixtures of soft and hard martensite at the higher strength levels. This behavior does not appear to involve a soft grain boundary network.

While there is some loss of ductility when high-temperature bainite is present in the microstructure, it is relatively low for amounts up to about 15%. Thus, a heat treatment involving the formation of small amounts of high-temperature bainite prior to quenching for martensite appears to be feasible.

H. J. ELMENDORF

Silicon Improves Ultra High-Strength Steels

Digest of "Effect of Silicon on Transverse Properties and on Retained Austenite Content of High-Strength Steels", by John Vajda, John J. Hauser and Cyril Wells. © Preprint No. 24, 1956.

LOW TRANSVERSE DUCTILITY limits the usefulness of steel forgings heat treated to ultra high strength. Some alloy steels with silicon additions have their tensile strengths significantly increased with no attendant decrease in ductility or notch toughness when heat treated to strengths in the range of 260,000 to 300,000 psi.

The present investigation was intended to supplement available information with data on transverse mechanical properties as they vary with silicon, and to correlate these properties with the microstructure. Three Ni-Cr-Mo steels of the A.I.S.I. 4340 type containing 1.25, 1.0 and 1.5% silicon were investigated over the wide range of quenched and tempered structures existing in end-quenched 7-in. rounds.

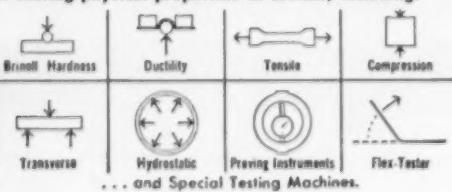
Increased hardenability and resistance to softening during tempering, which had been reported by other investigators in steels with extra silicon contents, were confirmed by the present tests. Silicon considerably increased the amounts of retained austenite, especially in the more slowly cooled portions, where as much as 27% austenite was found in the 4340 plus 1.5% silicon steel.



Manufacturers of machines for testing physical properties of metals, including:

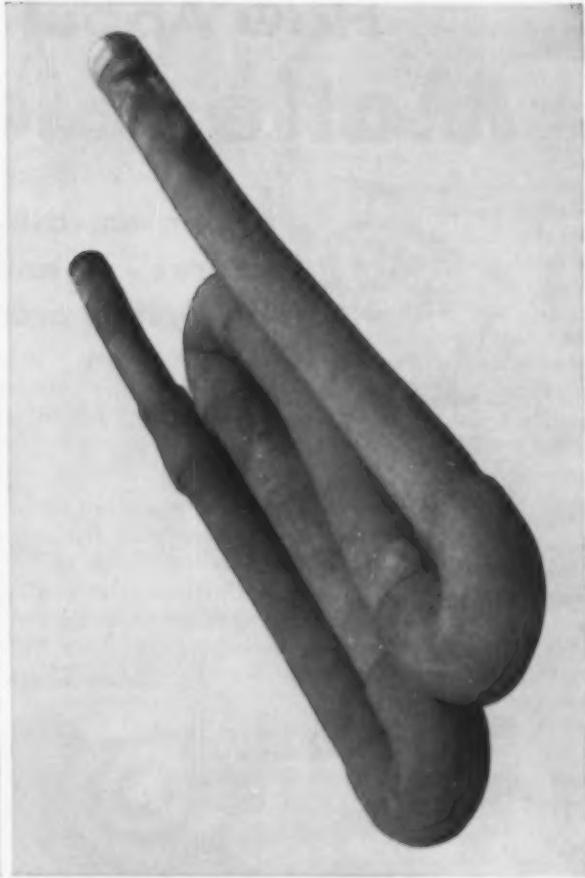
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This unretouched photograph shows deterioration of 25-12 alloy radiant tube after 10 months service.



This unretouched photograph shows radiant tube of NA22H still in serviceable condition after 78 months service in the hot zone where temperatures averaged 1850°F.

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After seven years of in-use testing in all heat zones of the furnaces, this user found that the service life of radiant tubes made of NA22H was increased far beyond the performance range of radiant tubes made of 25-12 type alloy.

After a total of 78 months service in temperatures

ranging from 1700 to 1925°F., the NA22H tubes were found to be in good condition and still continue in service. A 25-12 tube installed in the same position failed after 10 months service.

Since its introduction eight years ago, NA22H has proven itself in many applications where severe operating conditions and elevated temperature ranges are the rule.

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High-Strength Steel . . .

(The base alloy with 0.25% Si contained 4% austenite under similar conditions.) No significant detrimental effect of this much retained austenite on the mechanical properties was observed. Improvement in the transverse tensile and yield strengths on tempering the high-silicon steel at 500 and 600° F. was thought to be due to stress relief, since no significant additional amount of austenite transformed at those tempering temperatures.

The most favorable combinations of transverse strength and ductility were obtained with the highest silicon steel after tempering at 500° F. The results indicated that aircraft quality A.I.S.I. 4340 to which 1.5% silicon has been added can be tempered as high as 500° F. to give in fully quenched forgings a tensile strength of about 280,000 psi., together with relatively high transverse reduction of area (15 to 20%) and transverse notched impact values of 10 to 12 ft-lb.

H. Y. HUNSICKER

Impact Properties of Leaded Steels

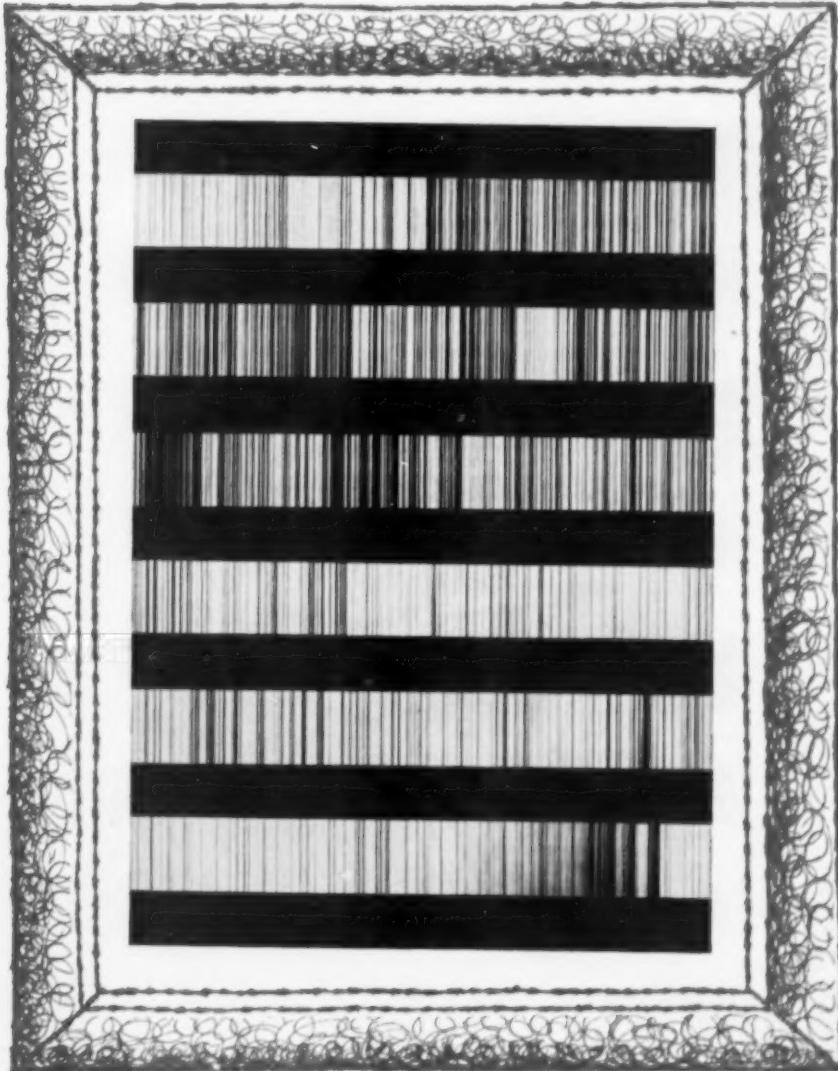
Digest of "Impact Characteristics and Mechanical Properties of Leaded and Non-Leaded C-1050 and C-1141 Steels", by A. P. Weaver. © Preprint No. 22, 1956.

ALTHOUGH the effect of lead additions to steel on hardness and tensile properties is well known, adequate information about Charpy impact properties has not heretofore been available.

Two alloys, C 1050 and C 1141, were studied. Two consecutive ingots were chosen from the middle portion of one heat of C 1141 and from two heats of C 1050, one made by fine-grain and the other by coarse-grain practice. Lead was added (0.20 to 0.30%) to one ingot from each heat.

Brinell hardness tests, tensile tests and Charpy V-notch impact tests were made on all materials as hot rolled and also on the C 1141 steel in the cold drawn condition. Samples were also tested after normalizing and after quenching and tempering.

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Leaded Steels . . .

There was little or no difference in tensile properties of any of the alloys because of the lead additions. Hardness of the C 1141 was not affected by lead but there was a slight reduction in hardness in the leaded C 1050 samples.

In virtually all samples, the Charpy V-notch impact transition temperatures were lower for the leaded steels than the nonleaded steels of the same grade and composition. The impact energies of the leaded materials were higher at temperatures below some point above or in the upper portion of the transition temperature range. The

nonleaded materials had the higher impact energies above the transition range. Normalizing increased the energy required to break the impact test specimens and a quench and temper resulted in even higher impact energies and lower transition temperatures.

Brittle fracture curves were included in the report and were in agreement in nearly all instances with the impact energy curves. At a specific temperature, the nonleaded steels show a higher percentage of brittle fracture and higher transition ranges than the leaded alloys. The leaded steels as hot rolled have finer grain structure than corresponding nonleaded samples.

E. S. RIDER

Ductile Chromium Metal

Digest of "Mechanical Properties of Swaged Iodide-Base Chromium and Chromium Alloys", by D. J. Maykuth and R. I. Jaffee. © Preprint No. 38, 1956.

CONSIDERABLE interest in ductile chromium has been shown for several years. Since chromium is usually quite brittle, much effort has been devoted to preparation of the metal in a high degree of purity. The cause of room-temperature brittleness has also been controversial; suggestions range from transition temperature effects to grain boundary precipitation. Chromium and chromium-base alloys are of interest for gas turbine applications because of their high strength and good corrosion resistance.

By modifications to the van Arkel process, chromium has recently been produced containing less than 5 ppm. oxygen and nitrogen. Data on this high-purity chromium and alloys made from it are reported.

Crystal bar chromium was melted on a copper hearth, hot forged at 1250° C. (2280° F.) and sheathed in iron and swaged to rod at 800° C. (1475° F.). A section annealed 1 hr. at 600° C. (1110° F.) and water quenched was machined into a tensile bar; this had ultimate strength of 60,000 psi., 44% elongation in 2-in. gage length, and 78% reduction in area. This is the greatest ductility ever reported for chromium metal.

A sample of the same rod, after recrystallizing at 816° C. (1500° F.), had tensile strength of 41,000 psi., no elongation or reduction in area, and broke with brittle fracture. Dynamic measurements showed an elastic modulus of 42,000,000 psi. at room temperature, decreasing to 36,000,000 at 800° C. (1475° F.).

Alloys of chromium containing 40% and 50% iron showed decreasing strengths and increasing elongations with increasing alloy content in the forged and swaged condition. Nickel alloys exhibited similar trends; however, the 40% nickel, 60% chromium has a vanishing amount of ductility.

The modulus of elasticity of both alloy systems was determined as a function of temperature. It ranged from 31,000,000 to 33,500,000 psi. at room temperature and 22,000,000 to 25,000,000 psi. at 1500° F.

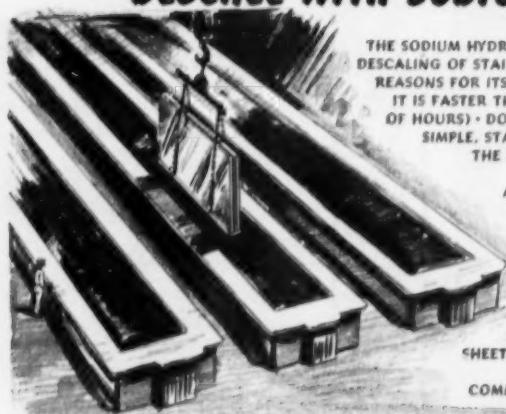
J. L. WYATT

keeping up with

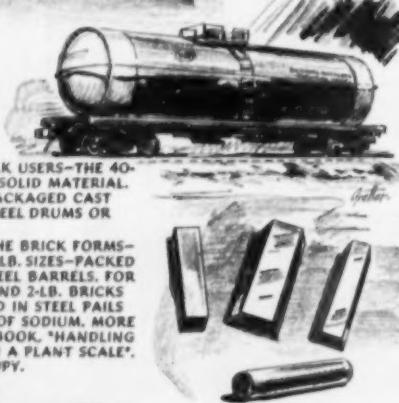
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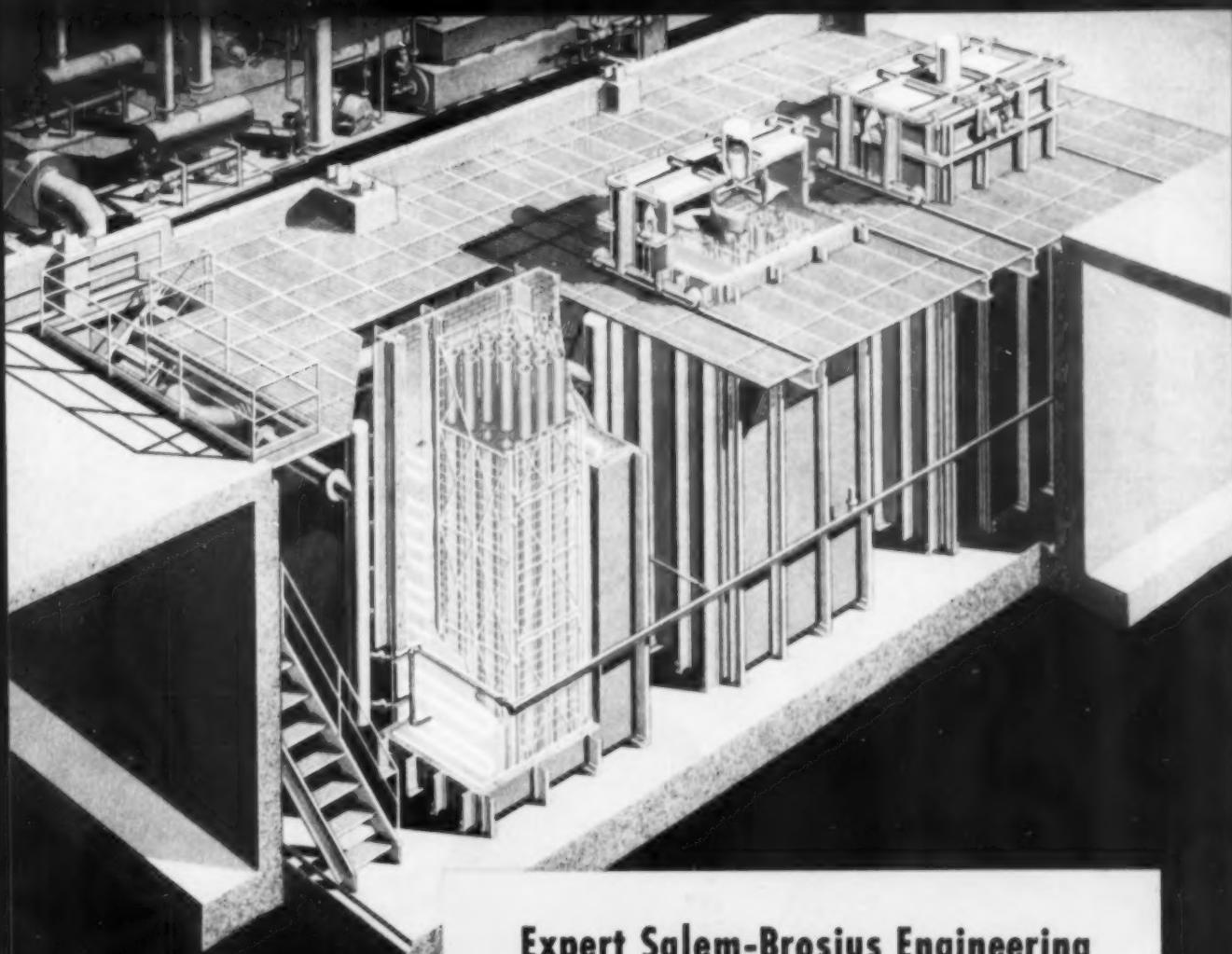
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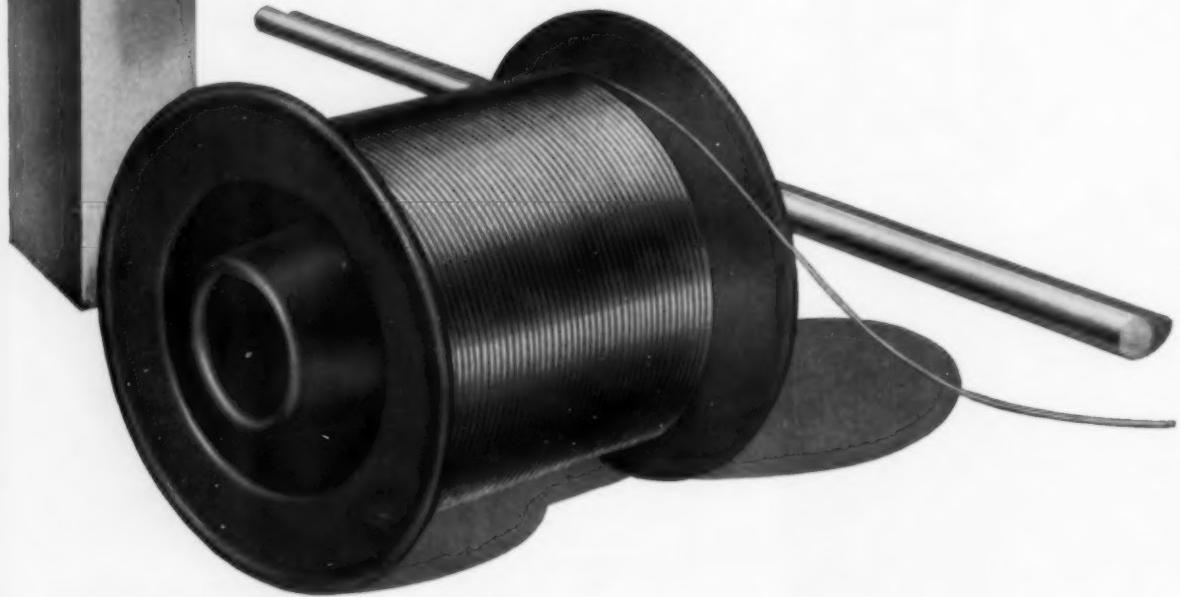
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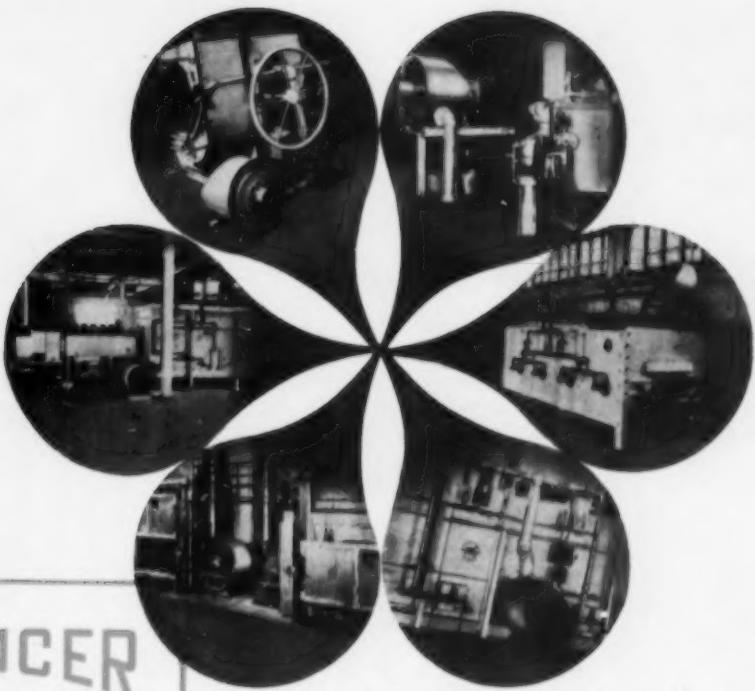
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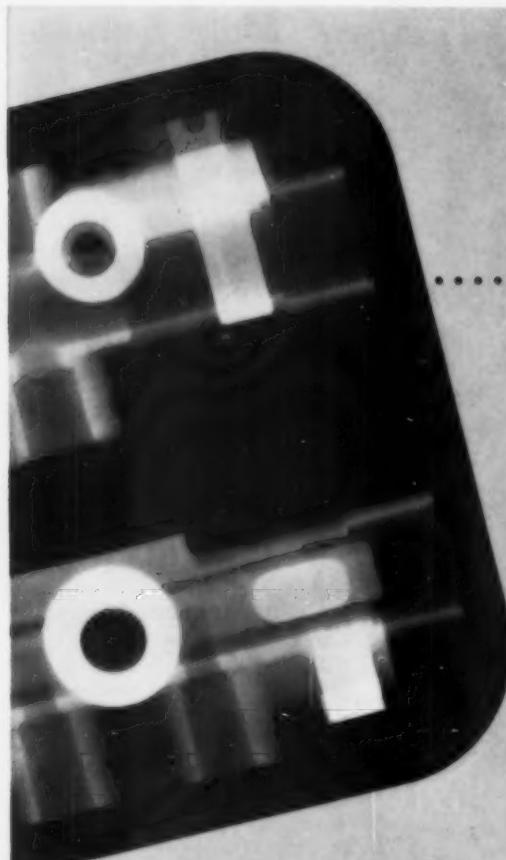
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"Brittle" Fracture in Gray Iron

Digest of "The Deformation and Rupture of Gray Cast Iron", by W. R. Clough and M. E. Shank. Preprint No. 8, 1956.

ALL GRAY CAST IRONS have small ductility in tension, a compressive strength 2½ to 4 times the tensile strength, and no "proportional limit" because tensile stress is not proportional to strain at any loading. The internal notching effect of graphite doubtless introduces severe stress concentrations at the thin flakes. To study some of these phenomena, the authors determined some mechanical properties of thin-walled specimens and others under combined stress. Microscopic deformation was also examined, and density measured by immersion methods.

A cast iron of the following analysis was used: total carbon 3.0%, silicon 1.25%, manganese 0.60%, sulphur 0.015% and phosphorus 0.05%.

Most of the specimens had an almost 100% pearlitic matrix. Some specimens in which the microstructural effects of stress on deformation were studied under the microscope were heated 12 hr. at 1300° F. to an entirely ferritic matrix.

Tubular specimens, 1.375-in. ID and wall thickness of 0.050 in., were tested in tension while under internal pressure. Compression tests were also made on threaded specimens held rigidly on the ends by plates so that a tangential or hoop stress was superimposed. Stress ratios varied widely. Strains were measured by Type A-8 resistance strain gages.

The microscope revealed deformation in the matrix of ferritic iron at loads as low as 3000 psi. Axial stress-strain curves of the tensile tests and the equibiaxial tension tests (as well as all five of the tangential strain curves) were practically identical. This implies that maximum strain is determined only by maximum tensile stress. For such to be true, lateral contraction in the plastic range must have little effect.

Results of all tests were summarized as follows:

1. Gray iron plastically deforms at very low stress levels because of stress concentration at internal notches. Photomicrographs show de-

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Hot-pressed MoSi_2 at 1800° F has a stress-rupture strength far superior to cemented carbides, cast and forged alloys, cermets and unalloyed molybdenum metal. The short-time tensile strength at 2200° F is 42,800 psi; modulus of rupture 55,000 psi. However, the use of MoSi_2 above 1800° F may be limited by a rapidly decreasing creep strength. This limitation may be modified by addition of an oxide to the disilicide.

High purity MoSi_2 powder is now commercially available from the Electro Metallurgical Company, P. O. Box 580, Niagara Falls, N. Y.; Fansteel Metallurgical Corporation, North Chicago, Ill.; and Sylvania Electric Products, Inc., Towanda, Pa. It can be formed by hot-pressing, sintering or casting. The disilicide can also be coated on various materials by vapor deposition. For further information on molybdenum silicides, write Dept. 5 for our bulletin "Refractory Molybdenum Silicides", Climax Molybdenum Company, 500 Fifth Avenue, New York 36, New York. It includes information recently released by the National Advisory Committee on Aeronautics.

CLIMAX MOLYBDENUM

Gray Iron . . .

formation at stress levels as low as 3000 psi. Stress is not proportional to strain at *any* stress level—the material is not "elastic".

2. Gray iron decreases in density when under stress. This volume change is greater in tension but also is present in compression. Graphite flakes apparently open up along planes approximately perpendicular

to the applied stress. This stress is a tensile stress, which occurs in certain directions even when externally applied stresses are compressive.

3. Under combined tension-tension stress, the greatest macroscopic strain is a function of the greatest tensile stress. The larger part of the strain measured by the gages is not the small strain of the matrix but that resulting from opening up of graphite flakes. This also accounts for the small lateral contraction of

cast iron (about 0.28%) at tensile fracture. Density decreases, which accounts for lateral contraction being less than the accepted figure of 0.5.

4. Although the fracture of gray iron is similar to that of a fully brittle material, it is actually preceded by extensive but highly localized plastic deformation. Rupture results from interconnected ductile fractures across the ferrite and by splitting across graphite flakes.

5. Various fracture criteria suggested by other investigators do not adequately explain the mechanism of fracture of gray cast iron, which depends upon the solution of the problem of randomly spaced saucer-like particles in a plastic medium.

PAUL G. NELSON

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Microstructure of 18-8 Ti

Digest of "Metallography of Titanium-Stabilized 18-8 Stainless Steels", by T. V. Simpkinson. © Preprint No. 29, 1956.

THE MICROSTRUCTURE OF A.I.S.I. Type 321 normally consists of an austenite matrix with nonmetallic inclusions which are largely TiC and TiC-TiN solid solution phases, plus ferrite and sigma, depending on chemical composition and prior thermal history. This paper illustrates fully the many features of these microstructures.

The material studied was an induction furnace heat cast into a keel block. A vertical slice was forged into a bar with reduction of ten to one. Most of the photomicrographs are from the cast material, because the amount and distribution of the phases are more favorable in the cast state.

Time and temperature required for formation and solution of chromium carbide and the preferential formation of titanium carbide are illustrated together with the proper etching techniques necessary to distinguish the phases. The fine dot-like carbide occurring in cast Type 321 is investigated; the author concludes that it is chromium carbide rather than fine sigma.

Sigma phases in cast and wrought samples are described separately. The effects of heat treatment on transformation and solution of sigma are illustrated. The effect of alumi-

Tool Steel Topics



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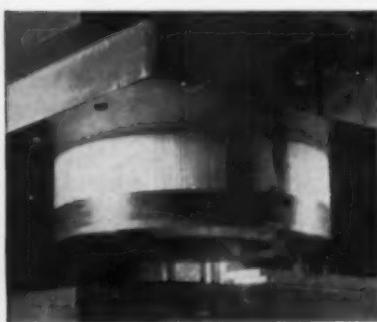
The dies, hardened to approximately Rockwell C 60, and operating in a 100-

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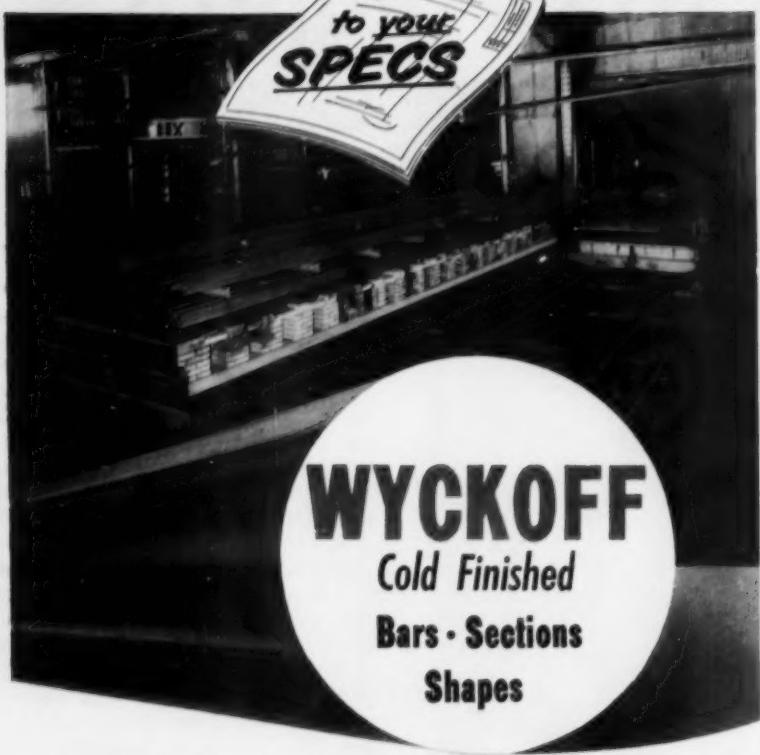
If tools are to be liquid quenched, all the bark must be removed to avoid excessively high quenching stresses which could cause cracking of tools during hardening. Low carbon areas on the surface transform during hardening at a different time than the higher carbon interior. This sets up additional stress which, added to the high thermal stresses from quenching, could cause cracking. Air-hardened tools can tolerate bark on non-working areas because of the low hardening stresses in air hardening. But with liquid-quenched tools there are no exceptions—remove all the bark.



"Teamwork," Bethlehem's new motion picture on tool steel, received a second film award, a silver reel symbolic of excellence, at the recent American Film Assembly competition in Chicago.

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Microstructure . . .

num content on sigma formation is noted. It was shown that the commonly recommended stabilizing heat treatment of 1 to 2 hr. at 1550° F. transforms the grain-boundary ferrite largely to sigma and new austenite. 1650° F. is usually too hot for sigma formation.

A few of the conclusions are:

1. In the as-cast condition some sigma phase is present in certain ferrite islands located at grain boundaries, but no sigma is detected in ferrite islands located within the austenite grains.
2. Chromium carbide is largely dissolved by 1 to 2 hr. at 1650° F., or in a shorter time at higher temperature.
3. A temperature of 1750° F. or higher is necessary to dissolve all of the sigma phase during 30-min. heating.

4. During *initial* heating of cast Type 321 at 1650 to 1750° F. much TiC is precipitated in a heavy dispersion. Even when the *initial* heating temperature of the casting was considerably higher (up to about 2100° F.), such precipitation occurred, the amount decreasing with the higher temperature.

5. The heat treatment commonly specified for testing susceptibility of 18-8 grades to "sensitization", namely 1 to 2 hr. at 1200 to 1250° F., produced a small amount of sigma. However, it does not seem likely that this would have an important influence on corrosion.

D. J. CARNEY

Changes in Modulus With Alloying

Digest of "The Influence of Alloying on the Elastic Modulus of Titanium Alloys", by W. H. Graft, D. W. Levinson and W. Rostoker. Preprint No. 10, 1956.

STRUCTURAL MATERIALS for aircraft applications should have high ratios of strength and modulus of elasticity to density. Much work has been done to improve strength-weight ratios, and in this paper the feasibility of increasing the modulus-to-density ratio of titanium by alloying was investigated.

The dynamic modulus of elasticity

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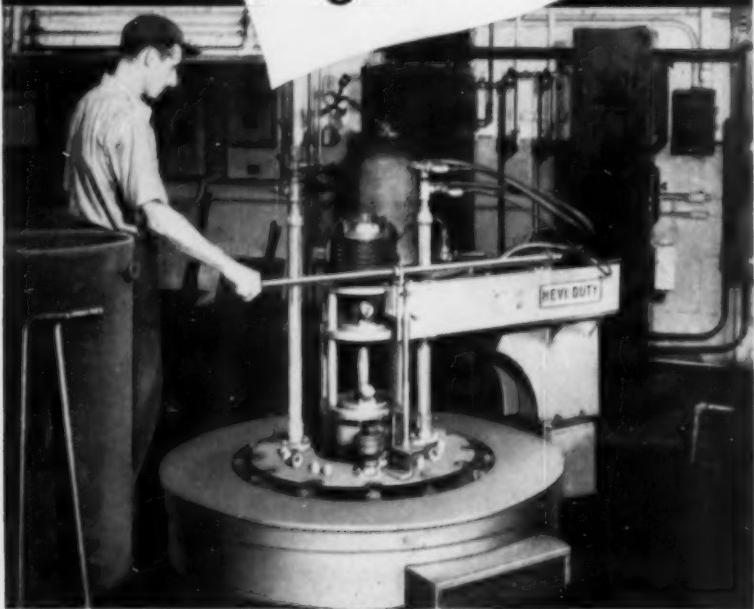
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Modulus of Ti . . .

was measured at temperatures between 70 and 750° F., using an electrostatic device. A bar of uniform cross section and length, L, was suspended by its middle and vibrated electrostatically from one end by a sine wave generator. At the resonant frequency for the fundamental vibration, f_n , the bar ends vibrate through large amplitudes while the center is a node. This is readily detected. The absolute value of the modulus may be calculated from the equation $E = 4 L^2 f_n^2 d$, where d is the density.

The variation of E or E/d with temperature was found to be linear. Thus, the modulus of elasticity of unalloyed titanium decreased from 16.2×10^6 psi. at room temperature to 12.6×10^6 psi. at 750°. Beta titanium was found to have a lower modulus of about 12 to 14×10^6 psi. at room temperature, as measured on a group of alloys which retained soft beta after quenching.

Aluminum up to 8% was found to increase the modulus and decrease the density, in agreement with earlier findings. Oxygen and nitrogen had little effect up to 0.6 and 0.7% respectively — well beyond the impurity limits for these interstitial elements.

Compound-forming elements, particularly up to 2.7% carbon and 1.4% boron, had a potent effect in increasing the modulus of elasticity to 20×10^6 psi. The other compound-formers, such as silicon up to 1.6%, beryllium up to 1.4%, and copper up to 11.5%, increased the modulus to about 17.3×10^6 psi. None of these elements increased E/d significantly over that for the 8% aluminum alloy (11.8 at 70° F., 10.6 at 500° F., and 10.0 at 750° F.). Effects of solid-solution alloying are additive to that of compound formation. Thus an alloy of 6% Al and 0.6% C had a modulus of 19.2×10^6 psi. at 70° F.

The modulus of alpha-prime in an alloy with 10% vanadium was rather low, about 9×10^6 psi. The presence of omega, the transition phase found in low-temperature aging of beta, was associated with a high modulus of about 20×10^6 psi. In alpha-beta alloys, the modulus values were found to be intermediate between those of alpha and beta titanium and to vary with the relative percentages of each.

R. I. JAFFEE

Mechanical Equation of State

Digest of "Effect of Strain Rate and Temperature on the Plastic Deformation of High-Purity Aluminum", by T. A. Trozera, O. D. Sherby and J. E. Dorn. Preprint No. 4, 1956.

THE MECHANICAL equation of state, as originally proposed by Zener and Hollomon, suggested that the flow stress is a function of strain and of a second term Z . Z is the product of strain rate and an exponential function of the activation energy for plastic flow. Qualitatively, this relationship suggests that greater flow stresses are found as the strain and strain rate increase and as the temperature decreases.

Dorn had shown that this mechanical equation of state is not strictly valid, since the flow stress depends also on previous plastic flow as well as the instantaneous strain and strain rate. In the present work, they attempt to determine if flow stress is a single valued function of strain when Z is kept constant. In this case the activation energy for plastic flow need not necessarily be constant, and a mechanical equation of state is not implied.

Aluminum sheet of 99.997% purity was machined into tensile specimens 0.100 in. thick, 0.250 in. wide and 1-in. gage section, and annealed 50 min. at 510° C. (950° F.) to equiaxed grain of about 1 mm. average diameter. These specimens were tested from -195 to 545° C. (-320 to 1015° F.) at four strain rates: 0.0035, 0.169, 7.0, and 600 per hr. True stress-strain curves were obtained for each set of conditions, and formed a nonintersecting homologous series of curves.

It was found that the curves of high strain rate and high temperature often overlapped curves of low strain rate and low temperature, showing that to some degree strain rate and temperature could be interchanged. The analysis of the stress-strain data was rather masterful. First, the curves were replotted in terms of flow stress versus temperature for constant strain values. From these, together with the original curves, curves were computed showing log strain rate versus inverse temperature, and from these in turn heat of activation was calculated.

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Equation . . .

A heat of activation of about 35,000 cal. per mol was associated with the low flow stresses resulting from high temperatures and low strain rates, and this value is the same as for the activation energy for self-diffusion, high-temperature creep, and grain-boundary shearing in the same high-purity aluminum. The authors conclude that the mechanism of plastic deformation in the low stress-strain curves is controlled by a "dislocation climb" process.

The activation energies for the higher stress-strain curves were lower, decreasing from 35,000 to 8700 cal. per mol, as $\ln Z$ increased from 29 to 34 per hr. In terms of low stress (at a strain of 0.15 for example), the low stress-strain curves correspond to flow stresses up to 1000 psi., while the high stress-strain curves correspond to flow stresses of 1000 to 12,000 psi. The authors suggest that the lower values of activation energy for plastic flow for the higher stress-strain curves arise from the greater amount of energy supplied mechanically, in turn due to the lesser energy required by thermal fluctuations.

R. I. JAFFEE

Transformation of U-Mo Alloys

Digest of "Transformation Kinetics of Uranium-Molybdenum Alloys", by R. J. Van Thyne and D. J. McPherson. Preprint No. 20, 1956.

THE TIME-TEMPERATURE relationships for the eutectoidal decomposition of the high-temperature gamma phase in uranium alloys containing up to 12% molybdenum were determined by isothermal transformation studies. Metallography, X-ray diffraction, electrical resistivity and hardness measurements were used to detect phase changes.

Samples containing 5.4, 8, 10 and 12% molybdenum were prepared by arc melting or by arc melting and vacuum casting. The protected specimens were annealed at 1832° F. and quenched into lead or lead-tin baths held at the transformation temperatures (390 to 1060° F.).

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U-Mo Alloys . . .

body-centered cubic gamma phase decomposes into orthorhombic alpha-uranium and epsilon phase, an ordered body-centered tetragonal phase containing about 15.5% molybdenum. The eutectoid point is located at about 1070° F. and 11.5% molybdenum. This study indicates that the nose of the TTT-curve for the 5.4% Mo alloy is at 1020° F. and 0.1 hr. Transformation of the gamma phase begins in about 2 hr. at 750° F. and 100 hr. at 570° F. No

decomposition was observed after 700 hr. at 390° F.

Longer times are required for the initiation of transformation in alloys with more than 5.4% molybdenum. The gamma phase in the alloy containing 12% Mo did not decompose after even 1000 hr. at 660° F.

The observed time for initiation of transformation depends on the method of measurement. Metallography is best for the detection of incipient transformation in the 5.4% Mo alloy and measurement of electrical resistance is best for alloys with higher molybdenum content. X-ray

diffraction is not satisfactory for determining when decomposition begins but is the best method of identifying decomposition products. The usefulness of hardness measurements is somewhat limited by pre-precipitation hardening.

R. F. STOOPS

Oxidation Resistance of Cr-Ni-Fe Alloys

Digest of "Some High-Temperature Oxidation Characteristics of Nickel With Chromium Additions", by G. E. Zima. Preprint No. 37, 1956.

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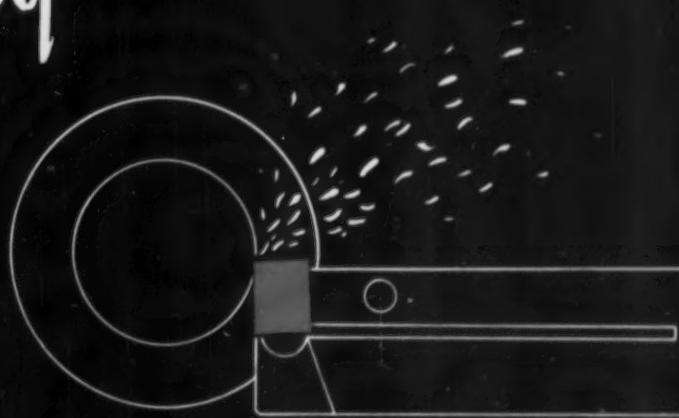
ALTHOUGH nickel-chromium alloys containing 16 to 20% Cr are among the most important bases for oxidation resistant alloys, there is surprisingly little information on the factors responsible for their low scaling rates.

Their oxidation behavior is complicated, with the oxidation rate of relatively low-chromium alloys being increased to a maximum before decreasing to the low values as the chromium reaches 20%. This paper attempts to clarify the effects of chromium on the NiO scale, which is of the metal-deficit p-type semiconducting class.

The alloys investigated contained 0.32 to 15% Cr by weight. (Supplemental data on a 20% alloy was supplied by E. A. Gulbransen of Westinghouse Research Laboratory.) The alloys were rolled to 0.020-in. strip and annealed at 2300° F. for 24 hr. to a large grain size. Oxidation tests were mostly at 2000° F. The alloys with up to 7.6% Cr oxidized according to the parabolic rate law, $W^2 = K_p t$, where W is the weight gain in g. per cc. and t is the time in seconds. Alloys with 8.7, 11.1, and 14.9% chromium were assumed to do the same and their K_p constants were averaged from multiple 6-hr. exposures at 2000° F. Gulbransen found that the 20% alloy also had a parabolic scaling curve at this same temperature. The ratio of scaling rates of the nickel-chromium alloys to pure nickel increased from 1 to 12.4 at 7.6% Cr, dropped sharply to 0.69 at 11.1% Cr, and then more gradually to 0.013 at 20% Cr.

The scales consisted of an outer massive green-black layer of NiO containing more and more dispersed

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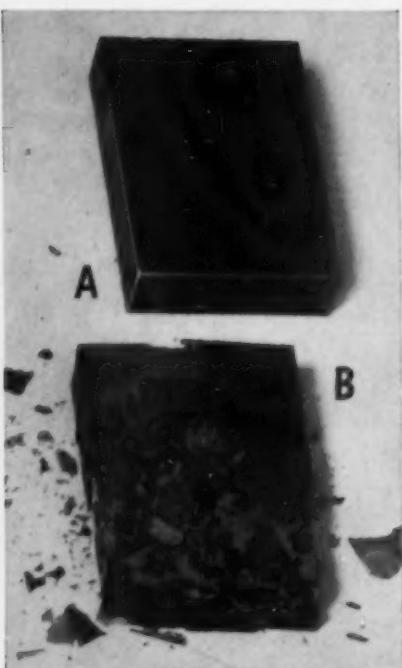
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A square of K161B Kentanium and a similar square of a well-known, heat-resistant 35 chromium-15 nickel alloy were exposed for 120 hours in an unsealed muffle furnace heated to 2000°F. The accompanying photographs vividly show how each piece was affected. While Kentanium is still good for hours of exposure at high temperatures, the nickel-chrome alloy has oxidized badly and has begun to disintegrate.

This demonstration suggests how well Kentanium will perform in such applications as furnace parts, heat-treating fixtures, quench guide rings, turbine blades, nozzle vanes, bushings and other parts where strength at high temperature, plus high resistance to oxidation, are factors.

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(Photo A) Kentanium shows only slight oxidation after test and is good for many more hours' exposure at 2000°F. (Photo B) Hard nickel-chromium (35%) alloy is badly oxidized and began to disintegrate during test.



Cr-Ni-Fe Alloys . . .

Cr_2O_3 crystals as the chromium content increased, and a powdery substrate under this scale whose amount also increased with chromium. During cooling, the outer layer of NiO separated from the substrate to a greater extent as the chromium content increased. The substrate was found to consist of NiO, Cr_2O_3 , and a spinel (NiCr_2O_4). The concentration of the spinel increased to a maximum at 8.7% Cr (approximately the content of maximum oxidation rate) and decreased to practically nothing at 14.9% Cr. The concentration of Cr_2O_3 increased progressively as the chromium content increased; at the metal interface, the substrate was believed to consist entirely of a layer of Cr_2O_3 . The coincidence of the highest oxidation rate with the peak content of spinel, and the lowest oxidation rate with increasing Cr_2O_3 , is significant.

In analyzing the substrate after deep scribing, some metal lines corresponding to substantially unalloyed nickel were found. This would suggest that Cr_2O_3 enters the oxide by reduction of NiO by chromium.

The lattice constant of the NiO in the scale decreases to a minimum at 2% Cr, as the lattice becomes saturated with chromium. However, for thin samples that were totally oxidized, the minimum in the NiO lattice constant and the apparent chromium solubility occurred at about 4% Cr in the oxide. This suggests that the conditions existing in the scale depart considerably from equilibrium. Beyond 2% Cr, the lattice constant of NiO increases, apparently because of interstitial solution of one or more of the ions involved.

According to the oxidation theory based on the defect model, it was expected that the initially decreased oxidation resistance would correspond to an increased number of nickel ion vacancies until the chromium was saturated. This was not found to be true. In general, the experimental results were much more complicated than could be explained by simple models based on defects in the NiO lattice or mixed Ni-Cr oxide lattices. The authors conclude that the Cr_2O_3 rather than the spinel imparts oxidation resistance to the Ni-Cr alloys.

R. I. JAFFEE



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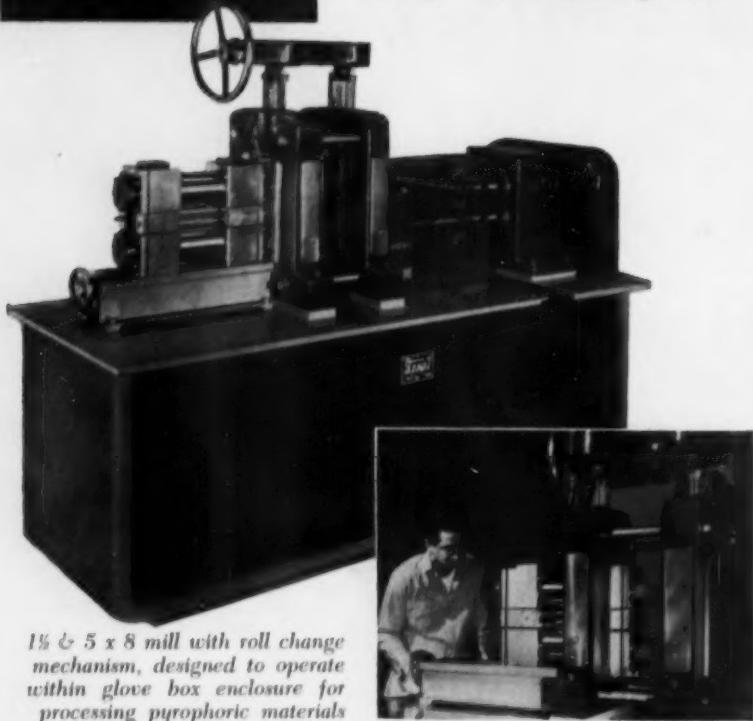
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Work Hardening High-Manganese Steel

Digest of "Transformation Products in Cold-Worked Austenitic Manganese Steel", by R. K. Buhr, S. L. Gertsman and J. Reekie. Preprint No. 28, 1956.

MANY THEORIES have been proposed to explain the marked increase in hardness of austenitic manganese steel obtained by cold working. Early investigators thought that part of the austenite transformed to martensite and that the transformation occurred in the slip planes produced by cold working the steel. Since the presence of transformation products in the strained steel could not be detected, an alternate theory suggests that the increase in hardness is the result of grain fragmentation and interlocking and blocking effects along the slip planes within austenitic grains.

Samples were prepared from two heats of steel having compositions of 1.25% C, 14% Mn and 1% Si. They were cold worked by dropping a steel weight from various heights so that the weight struck a conical portion of the specimen. A range of impacts from 10 to 150 ft-lb. was used.

The manganese steel was paramagnetic, or very nearly so, when in the unworked condition at 77° F. The value for susceptibility was high, about 28×10^{-6} electromagnetic units per g. After impact, each specimen was mounted in a susceptibility balance and the force exerted on it was measured for a number of field strengths at 77° F. The temperature variation of magnetization was investigated by mounting a small tubular furnace around the specimen between the poles of the electromagnet.

Cold working produces a ferromagnetic component. In a constant field, the amount of magnetization increases with increasing amounts of cold work until a maximum value is reached after which it decreases slightly. Estimates were made of the approximate amount of ferromagnetic constituent and although the values are two or three times those indicated by data plots, it is clear that the amount involved is very small and that in this respect, the transformation differs markedly from that in austenitic stainless steels.

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Work Hardening . . .

the magnetization as a function of temperature and thus determine the nature of the ferromagnetic constituent for several cold worked samples. The results indicate that two ferromagnetic components may be involved, one with a Curie point near 250 to 300° F. and the other having a much higher Curie point. The former may be a complex car-

bide of manganese and iron and the latter may be alpha iron. Heating to 500° F., even for 20 min., causes a stable increase in magnetization.

The lower impact loads do not work harden the specimens throughout and the maximum hardness occurs at a point below the surface of the cold worked specimens. A rough correlation was found to exist between the "average hardness" and the amount of ferromagnetic constituent produced.

Direct visual evidence was obtained of the existence of a ferromagnetic constituent produced by cold work by using a magnetic colloid technique. A replica electron micrograph of a severely cold worked sample shows sets of parallel lines resulting from severe etch attack along regions of slip bands. They are believed to be due to the formation of a fast-etching secondary phase along slip planes by the cold working strains. These characteristic sets of lines are not present in replicas of unworked specimens.

In summary, when austenitic manganese steel is cold worked by impact, a small quantity, probably not exceeding a few hundredths of a percent, of a ferromagnetic phase is formed. This phase is probably composed of two constituents, a complex carbide and alpha iron. The transformation product appears to be tempered martensite. Some correlation exists between hardness and the amount of ferromagnetic phase present in the cold worked steel. Magnetic colloid tests show the ferromagnetic constituents to be present along the traces of slip planes and along grain boundaries. The hardening mechanism may be similar to that which occurs in age hardening alloys.

G. A. FRITZLEN

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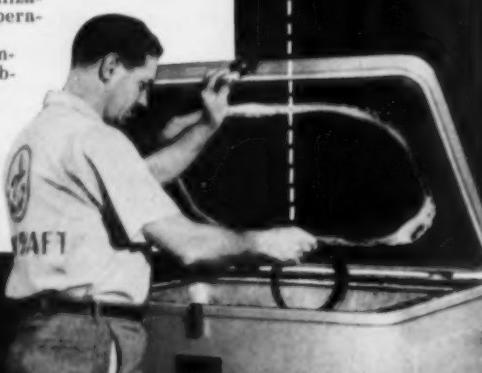
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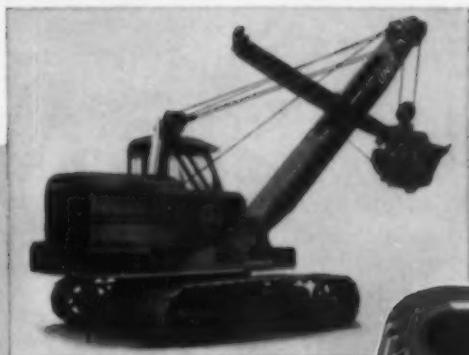


Evaluating Ultra High-Strength Steels

Digest of "Bend: Tensile Relationships For Tool Steels at High Strength Levels", by J. C. Hamaker, Jr., V. C. Strang and G. A. Roberts. Preprint No. 25, 1956.

IN EVALUATING the mechanical properties of ultra high-strength steels, hardness levels are reached where the bend test seems to offer more reliable and sensitive measurement of strength than the ordinary tensile test. Tensile test results may be erratic because slight misalignment of the specimen holders or small imperfections of the specimen surface can cause brittle failure at or below the yield point, thereby obviating any measurement of the tensile strength or relative ductility. Even when a complete load-extension curve is obtained, the small total deformation is not amenable to accurate measurement and the data show considerable scatter.

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The bend test has become a popular method of testing in recent years because specimens are relatively easy to prepare and the stress-strain characteristics can be determined readily with strain gages.

Two medium-alloy toolsteels, heat treated to various hardnesses, were tested in tension and in bending (single and double point loading) to obtain preliminary conversion relationships between the two test methods. In the hardness range from C-30 to 55, tensile strength was equivalent to 45 to 50% of bend strength and the 0.2% offset yield strength was equal to about 88% of bend yield strength. The relationship between tensile elongation and bend deflection is also shown.

The strength of three other toolsteels as a function of hardness was also determined to indicate the general utility of the bend test for evaluation of ultra high-strength materials. An interesting decrease in modulus of elasticity with increasing hardness was observed in three of the alloys.

H. J. ELMENDORF

Transformation of Uranium-Base Alloys

Digest of "Transformation Kinetics of Uranium-Niobium and Ternary Uranium-Molybdenum-Base Alloys", by R. J. Van Thyne and D. J. McPherson. © Preprint No. 19, 1956.

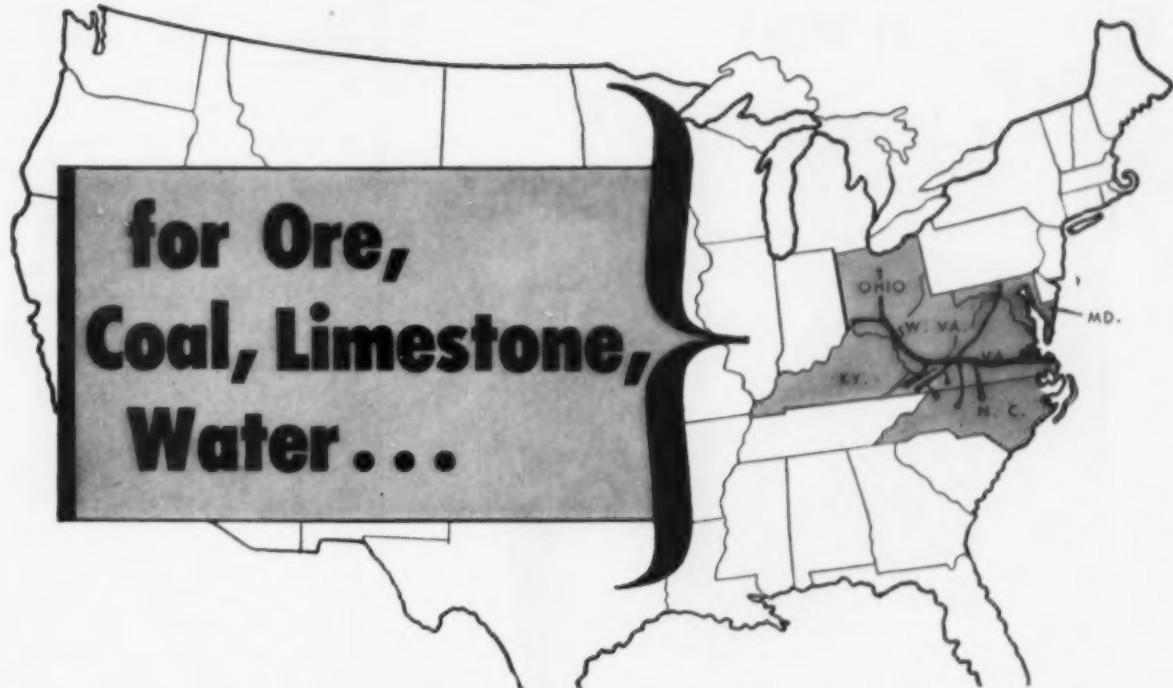
THE EFFECT of additions of columbium alone and in combination with molybdenum on the stability of the high-temperature gamma phase in uranium-base alloys was evaluated by determination of TTT-curves. Phase transformation was measured by metallographic examination, X-ray diffraction, hardness and electrical resistance.

Samples were prepared by arc melting or by arc melting and casting. The binary alloys were solution treated at 1920° F. and the ternary alloys at 1830° F. and quenched to the isothermal transformation temperatures.

The gamma phase in the 10 and 20% columbium alloys decomposes into orthorhombic alpha-uranium and another gamma phase containing about 60% Cb. Metallographic exam-

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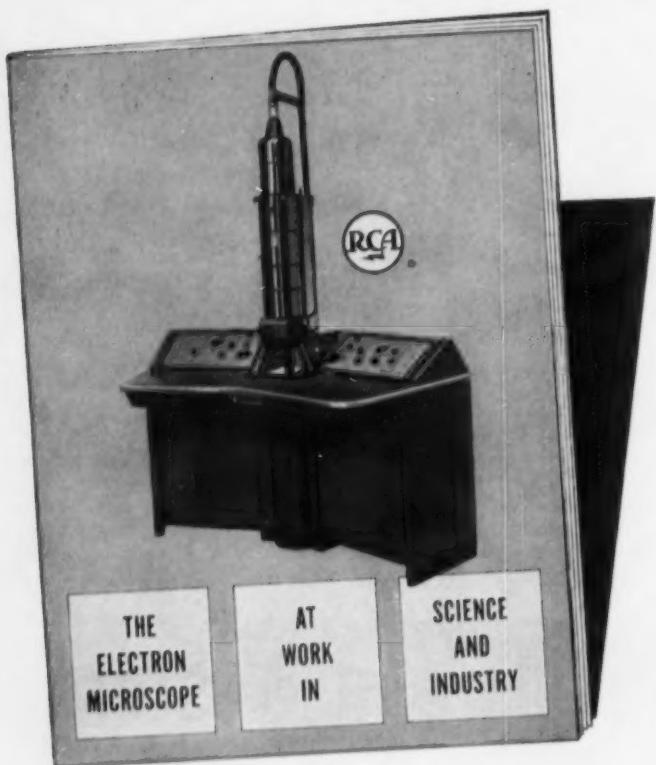
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Uranium Alloys . . .

ination indicates that the eutectoid temperature is between 1110 and 1200° F. The nose of the TTT-curve for the 10% Cb alloy is at about 1020° F. and 0.2 hr. Longer times are required for the 20% Cb alloy and the nose of its TTT-curve is at about 1020° F. and 10 hr.

The gamma phase in the ternary alloys decomposes into alpha-uranium and body-centered tetragonal epsilon phase. At 930° F., the gamma phase begins to transform in less time in the 8 Mo, 3 Cb alloy than in the 8 Mo, 1.5 Cb alloy. The stability of the gamma phase is apparently reduced by an increase in the columbium content. At temperatures below 750° F., the situation is reversed and the alloy with 3% columbium is the more stable.

The nose of the TTT-curve for an 8 Mo, 1 Pt alloy is at about 840° F. and 25 hr. After 1000 hr. of annealing at 930° F., this alloy is completely transformed. At lower temperatures transformation is not complete in any of the alloys after exposure up to 1000 hr.

The high-temperature gamma phase in uranium-base alloys is stabilized by the alloying elements tested. Extrapolation of the TTT-curves of the three ternary alloys indicates that the gamma phase in the 8 Mo, 3 Cb alloy is more stable at temperatures below 660° F. than gamma phase in the other two alloys.

R. F. STOOPS

**Effect of Sulphur
 in Titanium Alloys**

Digest of "The Effect of Sulphur on the Properties of Titanium and Titanium Alloys", by L. W. Berger, D. N. Williams and R. I. Jaffee. Preprint No. 12, 1956.

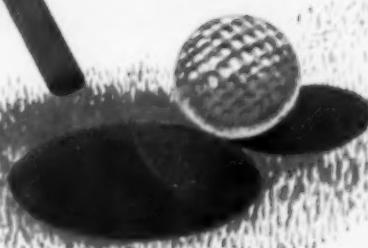
SULPHUR ADDITIONS to commercially pure titanium have been found to increase the tensile strength at concentrations up to 0.68% and cause a corresponding decline in ductility. This paper reports the effects of sulphur in both sponge-base and iodide-base binary titanium-sulphur alloys and the effects of minor amounts of sulphur in various commercial and

(Continued on p. 228)

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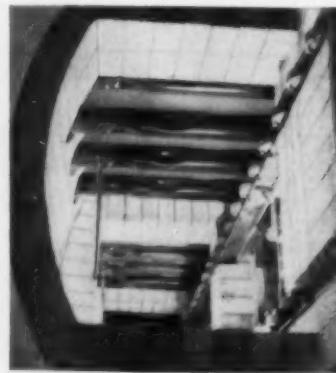
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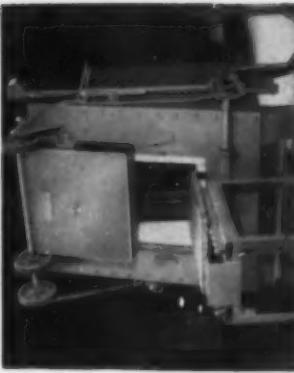
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Sulphur in Ti . . .

experimental alloys. Additions up to 18.5% sulphur were studied.

The room-temperature solubility of sulphur in titanium appears to be between 0.009 and 0.017%. Since an initial sharp increase in strength occurs before sulphides are evident in the microstructures of specimens, the considerable strengthening of titanium observed with a corresponding sharp decline in ductility probably results from solid-solution hardening.

Additions up to 0.025% cause significant increases in tensile and yield strengths. Sulphur up to 0.45% caused only a slight increase in strength and a decline in ductility.

As little as 0.004% sulphur refines the grain size of both as-cast and wrought titanium. The maximum effect is obtained with about 0.05% sulphur. Sulphide networks are formed in castings containing as little as 0.25% sulphur and they act as grain refiners. The networks may be broken up by subsequent working and annealing treatments. Annealing for long times in the alpha field causes considerable grain growth in the sulphide-containing alloys. Sulphur additions have little effect on the beta transus of titanium.

Additions of 0.2% sulphur to titanium alloys containing molybdenum, vanadium or aluminum plus vanadium cause a marked increase in yield strength with only a slight decline in ductility. This amount of sulphur is sufficient to refine the grain, both as-cast and wrought.

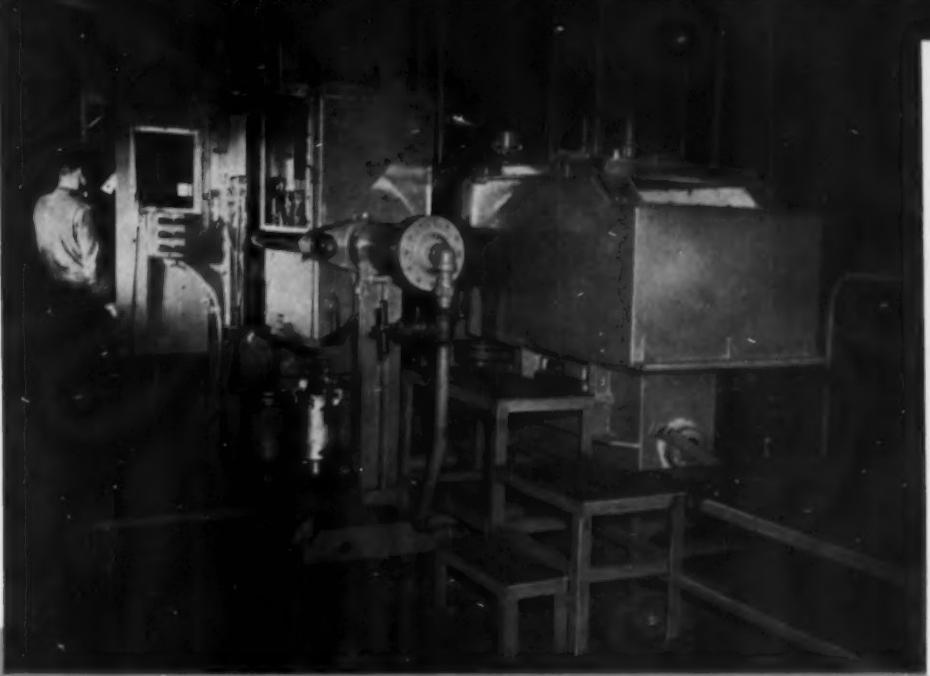
G. A. FRITZLEN

Complex Carbides in Cr-Co-Mo-Ti-Fe Alloys

Digest of "Influence of Molybdenum on the Phase Relations of a High-Temperature Alloy", by H. J. Beattie, Jr., and F. L. VerSnyder. Preprint No. 35, 1956.

A NUMBER of nickel-base alloys include molybdenum as an alloying element to impart strength at high temperature. Most of these alloys have one or more disperse carbide phases of the types $M_{23}C_6$ and M_6C , in both of which part of the (Continued on p. 232)

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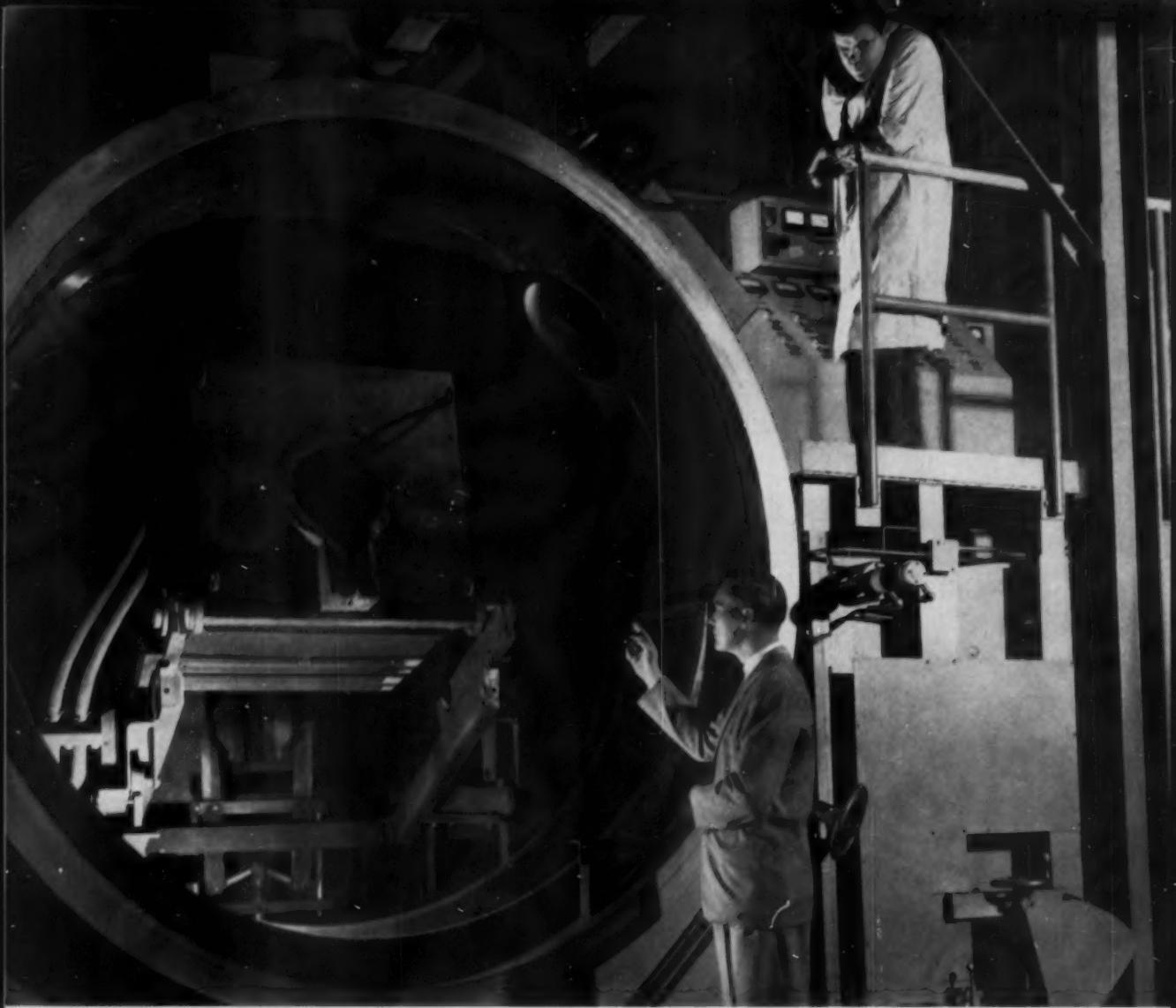
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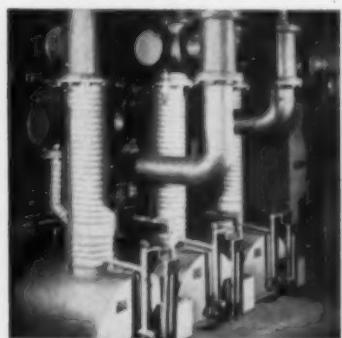
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- Microvac Pumps—Catalog 750
- Diffusion and Booster Pumps
- Specification and Performance Data
- Story of the Ring-Jet Pump
- How to Care for Your Vacuum Pump—
Booklet 755
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Complex Carbides . . .

metal atoms are known to be molybdenum. Its effects on the carbide phases and phase relationships have now been studied in some nickel-base alloys containing 0.1 to 0.2% carbon, 16 to 22% chromium, 10% cobalt, 2 to 3% titanium, 2 to 3% iron, and small quantities of aluminum, manganese, silicon and nitrogen. Molybdenum additions ranged from 2 to 11%.

All alloys were solution heat treated, then aged in the range 1200 to 1800° F. for 50 to 1000 hr. Examinations included electron diffraction and X-ray. Carbide particles were delineated by selective etching, and sometimes recovered for further study by dissolving the matrix.

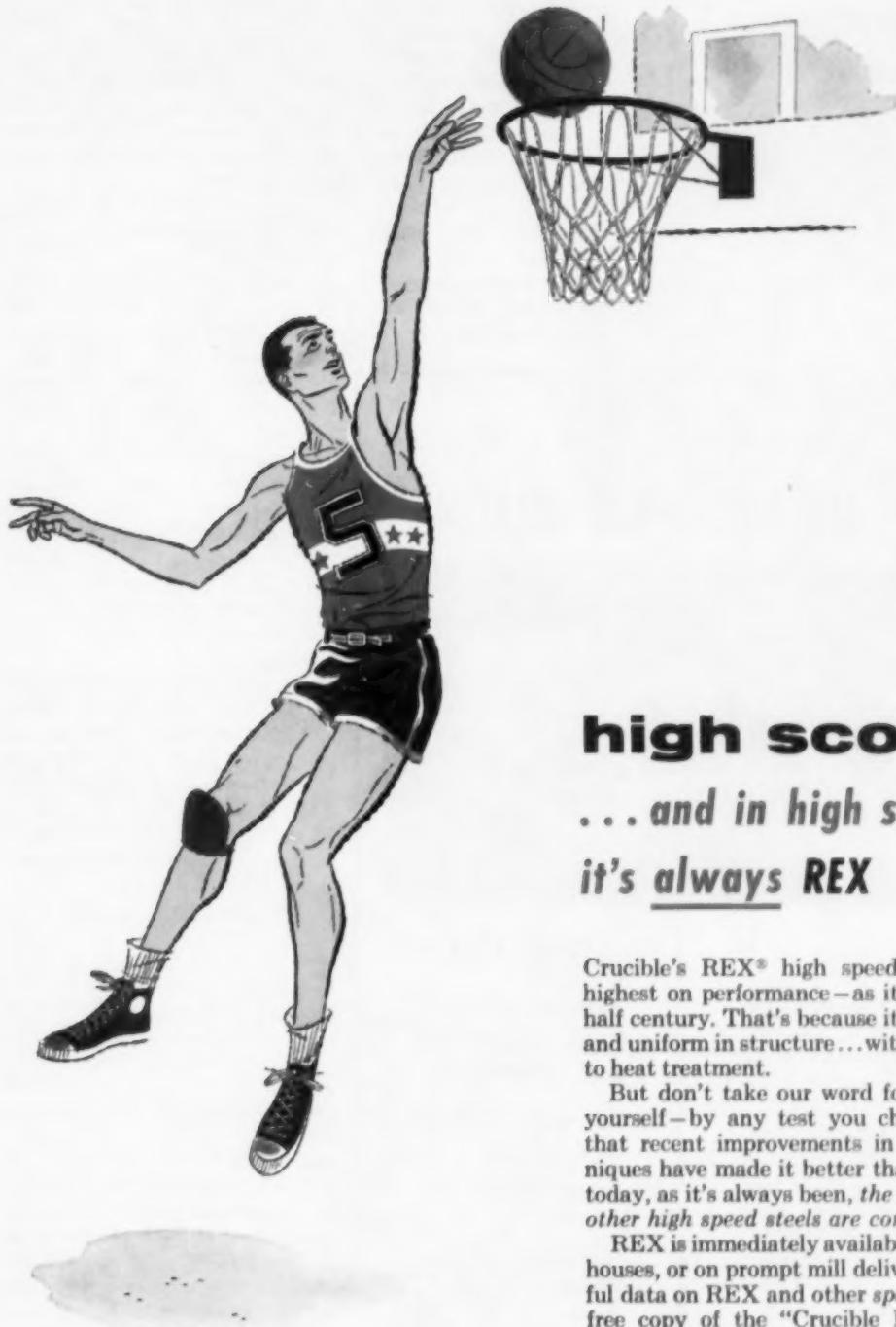
The action of titanium was of much interest. As the quantity of M_6C precipitate increased, the matrix solubility for titanium increased and the TiC disappeared. Titanium therefore does not suppress formation of complex carbides in these alloys. Types $M_{23}C_6$ and M_6C may precipitate simultaneously and co-exist, however.

Two types of precipitates were formed, namely, a disperse second phase, and a "cellular" precipitate largely at grain boundaries. The latter occurred at lower temperatures and after shorter aging times and seemed to be associated with the complex carbide, $M_{23}C_6$, only.

Stability of $M_{23}C_6$ is dependent on the amount of molybdenum present. The "cellular" $M_{23}C_6$ was stable in alloys containing up to 6% molybdenum; higher contents promoted the preferential formation of M_6C .

Lattice parameters of both the complex carbides increase with increasing molybdenum in the alloy. Two different M_6C carbides are reported in the alloys containing 8.5 and 11% molybdenum; only one of these has an expanding lattice. The phase with constant lattice size was relatively tightly packed: 10.85 Angstrom units. Duality of the M_6C carbide phase was also observed in alloys and after heat treatments that also produced sigma phase and a distinct break in the lattice parameter of the matrix metal. These facts are considered to be interrelated and may be a key to a better understanding of sigma phase formation.

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Ti and B in Heat Resistant Steels

Digest of "High-Temperature Rupture-Strength Properties of Chromium-Nickel Stainless Steels Containing Titanium and Boron", by J. Salvaggi and L. A. Yerkovich. Preprint No. 33, 1956.

STRENGTHENING of leaner alloys for aircraft construction was the purpose of this research. Using stainless

steels of Type 302 (18-8 Cr-Ni) and Type 316 (17-12-2.5 Cr-Ni-Mo), some 130 melts with 0.07 to 0.30% C were surveyed to define the effects of 0.15 to 1.50% Ti, 0.05 to 0.75% B, and their combinations on stress-rupture properties of hot rolled 0.050-in. sheet. Solution treatments at 2100, 2200 and 2300° F. were included, the higher temperatures being markedly beneficial when incipient fusion was avoided. Limiting rupture stress (LRS) for 100-hr. life at 1500 and 1350° F. was the criterion.

With 0.75% Ti and 0.15% C in 18-8, the maximum LRS at 1500° F. was 14,800 psi. This appears much superior to the 5000 to 6000 psi. expected from commercial Type 321 stainless, and may be due in considerable part to the solution treatment at 2300° F. Aging 100 hr. at 1350 or 1500° F. increases hardness from Rockwell B-75 to about B-88.

Boron at 0.40% (with 0.15% C) attained a maximum LRS of nearly 20,000 psi. at 1350° F. and 10,000 psi. at 1500° F., along with a three-fold increase in hot ductility (after a 2100° F. solution treatment). Precipitation hardening probably is a contributing factor, as aging for 100 hr. increased hardness from B-80 to about B-112, and a boride constituent appeared in the microstructure. Since boron encourages eutectic formation and lower melting points, its optimum use requires lower solution temperatures.

Titanium and boron together were beneficial after treating at 2100° F., with a peak LRS and high ductility at 1500° F. of 11,800 psi., compared to 10,000 psi. when boron or titanium was added alone. Optimum combinations were 0.07% C, 0.15% B, 0.15% Ti, and 0.15% C, 0.50% B, 0.15% Ti, with peaks occurring at progressively lower titanium contents as boron was increased.

Molybdenum-bearing Type 316 stainless sheet has an LRS expectancy of around 9000 psi. at 1500° F. This was boosted to about 18,500 psi. by 0.8% Ti and a 2300° F. treatment; 5% ductility implies a marked increase in creep resistance.

Boron in the 17-12-2.5 Cr-Ni-Mo base also increased LRS values at 1500° F. to 16,000 psi. with 0.15% C plus 0.15% B, and 18,000 psi. at 0.30% C plus 0.85% B (using a 2200° F. treatment). Again, hot ductility was increased after a solution treatment at 2100° F.: 55% with 0.07% C plus 0.27% B compared with 5.5% without boron. Solution temperatures above 2200° F. were undesirable, for a eutectic formed which interfered with hot rolling qualities.

Combinations of titanium and boron, with 2100° F. solution treatment, gave better results than these elements separately in the Type 316 base, and without loss of ductility. The peak was 15,700 psi. at 0.15% C, 0.50% B and 0.13% Ti. With 2300° F. treatment the peak was 20,600 psi., but ductility was only 2%. The com-

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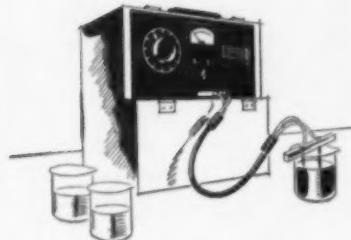


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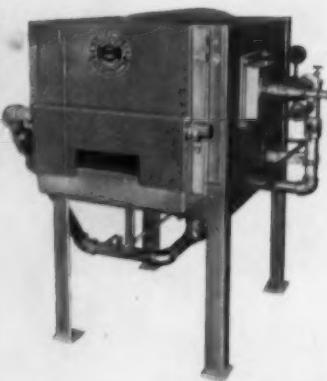
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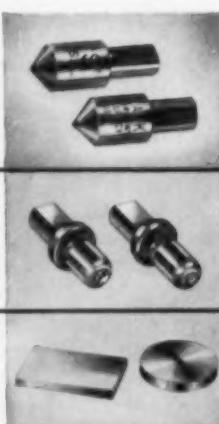
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Heat Resistant Steels . . .

position seemed to promote grain refinement; 1500° F. exposure developed fine precipitates which were better dispersed than in the Type 316 alloy, where they tended to follow grain boundaries. Boron appeared to encourage a peppery precipitate and after 2200° F. a eutectic was evident.

The unalloyed Type 316 base showed some evidence of intergranular oxidation after heating in air at 2300° F. In contrast, the Type 316 with 0.81% Ti retained a stable microstructure after solution treatment at 2300° F. and had an LRS of 18,500 psi. at 1500° F.

These benefits appear to be significant and an encouraging step in the search for leaner aircraft alloys.

H. S. AVERY

Precipitation Hardening of Cr-Mn Stainless Steels

Digest of "Precipitation Reactions in Austenitic Cr-Mn-C-N Stainless Steels", by Chi-Mei Hsiao and E. J. Dulis. © Preprint No. 26, 1956.

TWO TYPES of precipitation reactions occur during heat treatment of austenitic chromium-manganese-carbon-nitrogen steels. The first is characterized by the formation of lamellar nodules at grain boundaries. The second is a general precipitation which results in a structure of the Widmanstätten type.

Three steels were studied containing 13 to 17% manganese, 18 to 23% chromium, 0.40 to 0.43% carbon and 0.14 to 0.17% nitrogen. Samples were prepared from 15-lb. induction-melted heats by forging to $\frac{1}{4}$ -in. square bars. All were solution annealed at 2200° F. for 30 min. and water quenched. The aging treatments consisted of heating at temperatures between 1000 and 2000° F. for various times and water quenching. Some samples were quenched directly from the solution annealing temperature into lead baths at aging temperatures, held for various periods of time and water quenched.

Magnetic susceptibility measurements were used to establish austenite stability after heat treatment. Microstructures of the heat treated



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Cr-Mn Stainless . . .

steels were studied and lineal analyses were made to determine the kinetics of the grain boundary reaction. X-ray diffraction measurements of both electrolytically extracted residues and solid samples were used to identify the precipitated phases.

It was concluded that the formation of lamellar nodules at grain boundaries is predominant at aging

temperatures above 1500° F. On the other hand, this reaction is retarded at aging temperatures below 1500° F. and general precipitation is predominant. Slow cooling from the solution annealing temperature promotes the grain boundary type of precipitation.

The authors established that the grain boundary reaction is a nucleation and growth process. Thermodynamic treatment of the aging curves for this reaction indicates that the

activation energy is 57 kg-cal. per g-mol. in initial stages and 68 kg-cal. per g-mol. in the later stages.

All steels were nonmagnetic after heat treatment which indicates that neither austenite decomposition to ferrite nor austenite transformation to martensite occurred. The X-ray diffraction work revealed that lamellar nodules in the grain boundaries consisted of austenite and $M_{23}C_6$ carbide. The lattice constant of the austenite in the nodules was somewhat smaller (3.615 Å) than that of unaged austenite (3.652 Å). The composition of the carbide in the lamellar nodules was determined to be $(Cr_{17}Fe_4Mn_2)(C_{5.7}N_{0.3})$ when chemical analyses were compared with the distribution of alloying elements between the matrix and the precipitate.

Both types of precipitation reaction increased the hardness of the steels studied. General precipitation of the Widmanstätten type increased hardness more than grain boundary precipitation.

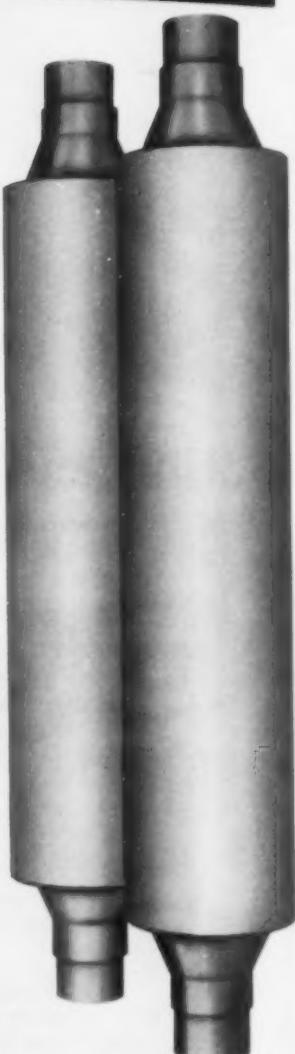
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Tensile Properties of Metals at Low Temperatures

Digest of "Some Exploratory Observations of the Tensile Properties of Metals at Very Low Temperatures", by E. T. Wessel, *Preprint No. 3, 1956*.

LOW-TEMPERATURE RESEARCH is making important contributions to a better understanding of the flow and fracture properties of metals. A considerable amount of information has been developed recently in connection with low-temperature embrittlement. Certain generalizations concerning the relationships between this phenomenon and crystal structure have been made. The present research covered tensile tests of metals having various lattice structures at temperatures ranging down to -452° F. Such tests have been made possible by the recent development of an automatically controlled refrigerating system employing liquid helium.

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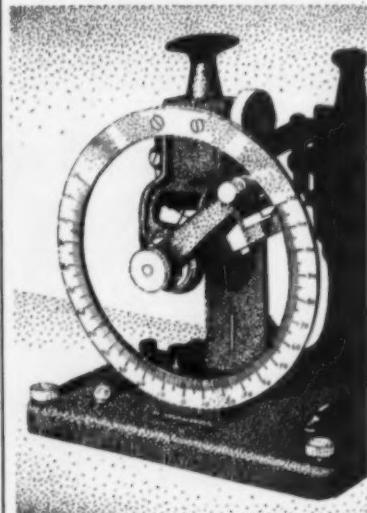
with decreasing temperature, the value at the lowest testing temperature being about double that at the highest temperature. A five-fold increase in the tensile strength occurred over the same temperature range. Uniform elongations of the nickel specimens were highest at the lowest testing temperature. The ductility remained high throughout the temperature range but dropped somewhat in the range -330 to 80° F., possibly as a result of precipitation of impurity elements.

Tensile properties of close-packed-hexagonal zirconium were affected by temperature change in about the same manner as those of nickel. The ductility was lower in the range -330 to 32° F., than at either lower or higher temperatures, an effect attributed to strain aging.

In contrast to nickel and zirconium, body-centered cubic beta brass showed a strong dependence of yield strength on temperature with an approximate seven-fold increase from room temperature to -452° F. Despite this precipitous rise in the yield strength, the brass exhibited relatively high ductility (20% uniform elongation) even at the lowest temperature.

The yield strength of quenched and tempered S.A.E. 4340 steel increased about 65% over the range from room temperature to -452° F. and the ductility decreased gradually, showing no sharp transition from ductile to brittle behavior.

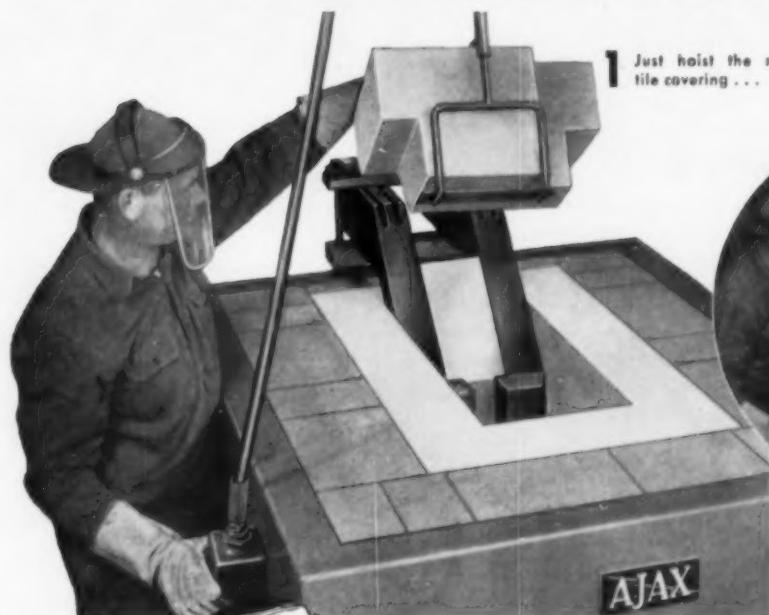
(Continued on p. 242)



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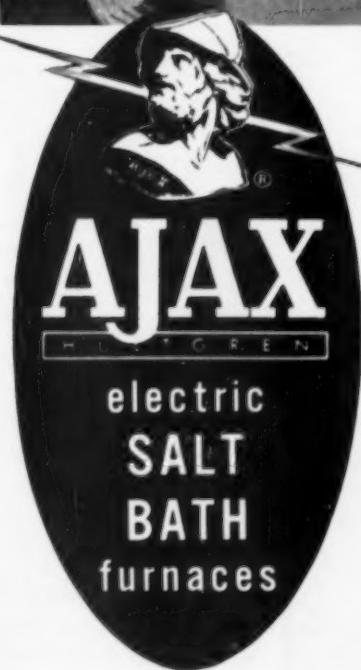
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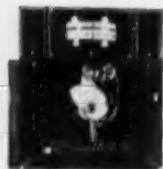
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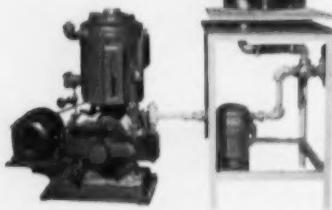


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Tensile Properties . . .

The value of reduction in area for quenched and tempered S.A.E. 3335 also decreases gradually with temperature but drops sharply at -300° F. However, even at -452° F. its reduction in area was 42%.

Despite the strong temperature dependence exhibited by the yield strengths of the body-centered cubic metals, the experimental results obtained at the lower temperatures failed to conform with either the Zener-Hollomon or Cottrell-Bilby flow stress temperature relationships which predict even greater yield strength increases than those observed. The yield strength behavior of the alloy steels tested was considered to represent the composite effects of two components; one was relatively independent of temperature and was accounted for by the dispersion of carbide particles and the other was associated with alloyed ferrite and was strongly temperature dependent.

H. Y. HUNSICKER

Growth of Uranium During Thermal Cycling

Digest of "The Plastic Deformation of Uranium on Thermal Cycling", by H. H. Chiswick. *E* Preprint No. 21, 1956.

THIS interesting study covers the interrelationships between the growth of uranium during thermal cycling and its grain size and orientation. The raw material for samples was beta-treated pure uranium rod. After suitable conditioning of structure, samples were subjected to thermal cycling between 50 and 550° C. (120 to 1020° F.) using a liquid bath of NaK in a furnace with special zone controls. The cycling conformed to a precise time schedule and was carried to a total of 700 cycles.

The data show that the greater the preferred orientation created by rolling, the greater the growth in thermal cycling when grain size is held constant. A reduction in area of 3% by rolling causes 11% growth in 700 thermal cycles; 74% reduction results in growth of 34%.

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Growth of Uranium . . .

in samples having a constant level of preferred orientation corresponding to 70% reduction is also created by variation of grain size. The larger grains (0.18 mm.) produce moderate growth (13%) whereas fine grains (0.014 mm.) contribute to marked growth (59%).

Microstructural studies revealed that continued cycling generates subgrains; this suggests that coarse-grained material might be expected to increase in growth with continued cycling because of these new grains. All samples developed internal porosity. This was unrelated to grain size, orientation or the amount of growth created. While no relationship to inclusions or grain boundaries was found, the presence of the pores is believed related to the impurities present. High-purity uranium (100 ppm. maximum impurity content) has been carried to 3000 cycles and 400% elongation without evidence of porosity.

An interesting chart of growth rate plotted against degree of anisotropy suggests that complete achievement of random orientation might eliminate growth from thermal cycling as controlled in these experiments.

J. A. FELLOWS

Austenite Stability of Fe-Cr-C-N Alloys

Digest of "Phase Relationships and Mechanical Properties of Some Iron-Chromium-Carbon-Nitrogen Alloys", by G. P. Tisinal and C. H. Samans. • Preprint No. 30, 1956.

AUSTENITE can be retained at room temperature by cooling properly balanced iron-chromium-carbon-nitrogen alloys rapidly from 2200° F. The austenite decomposes to ferrite plus carbides and nitrides when cooled at slower rates. The effect of lower quenching temperatures on austenite stability of such steels containing 21 to 23% chromium is reported in this paper.

The phase relationships were studied by X-ray diffraction, metallography, hardness testing and magnetic susceptibility measurements. For the X-ray determinations, samples consisted of filings sealed in Vycor tubes

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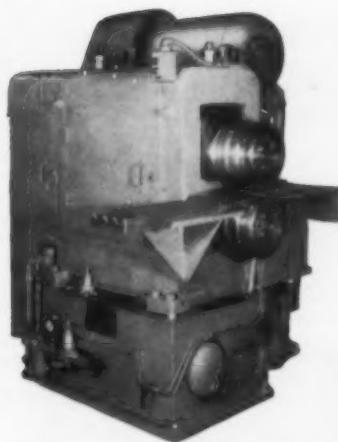
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Austenite Stability . . .

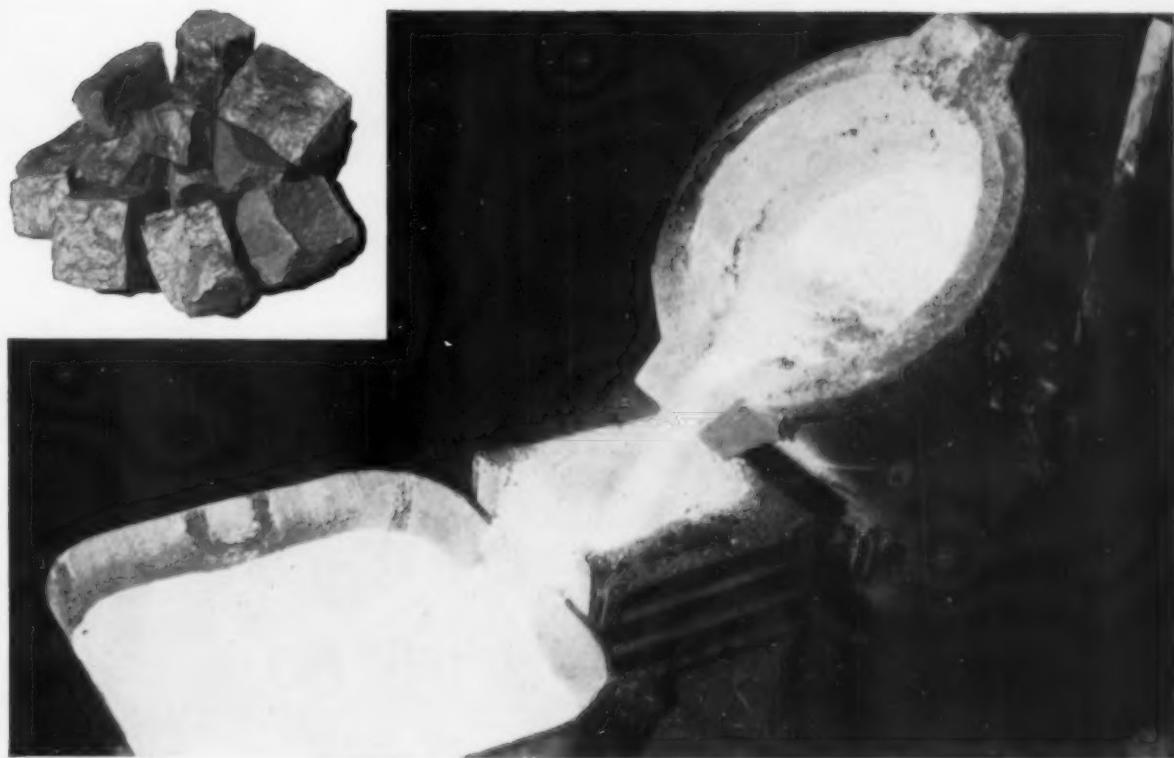
and heated at temperatures between 1300 and 2200° F. Solid samples were employed for the other methods of study. All samples were heated for 20 hr. and water quenched.

Metallographic examination was used to detect the following structures: free polygonal ferrite, lamellar ferrite formed in conjunction with carbides and nitrides as a result of austenite decomposition, stable austenite and martensite. X-ray diffraction techniques were employed to detect stable austenite and martensite and to determine the type of carbides



and nitrides present. Hardness data were used to follow the course of the martensite reaction. A Magne-Gage was used to indicate the presence of ferrite.

The martensite reaction was pronounced for all austenite formed below 2000° F. in the 21% chromium alloys. The maximum amount of martensite formation appeared in alloys quenched from 1700 to 1800° F. The martensite reaction was noted in 27% chromium alloys but to a lesser extent. No martensite was found in structures of the 33% chromium alloys. The martensite transformation is inhibited when the austenite of the alloy is sufficiently rich in chromium, nitrogen and carbon. In the 21 and 27% chromium alloys, heat treatment at high temperatures will dissolve sufficient carbon and nitrogen to enrich the austenite enough that martensite cannot form on quenching. (Continued on p. 252)



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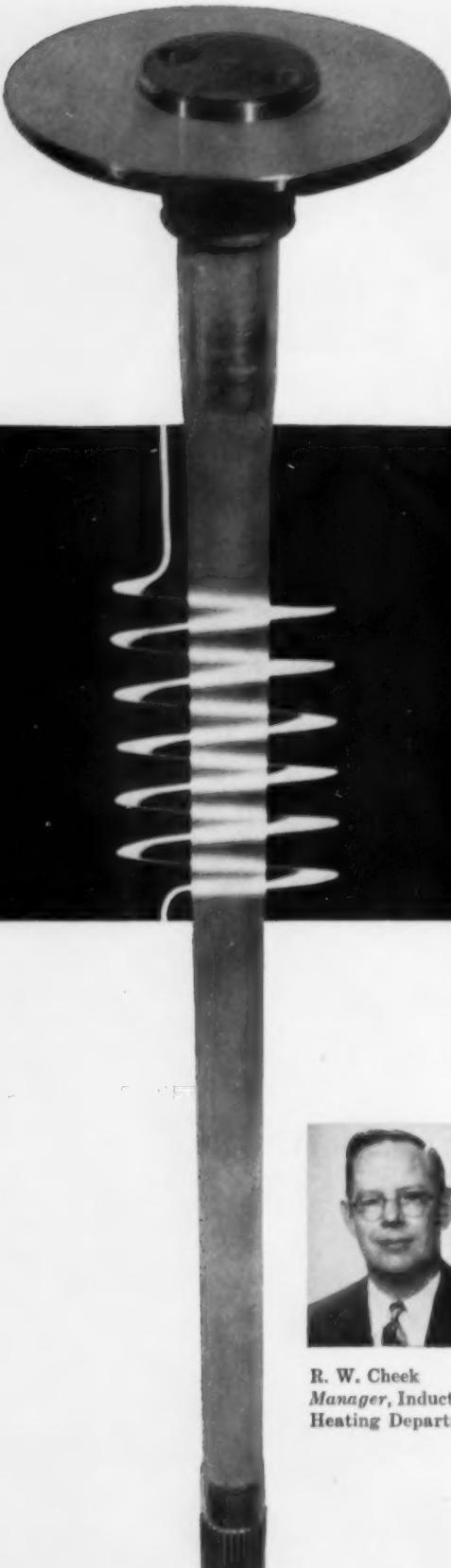
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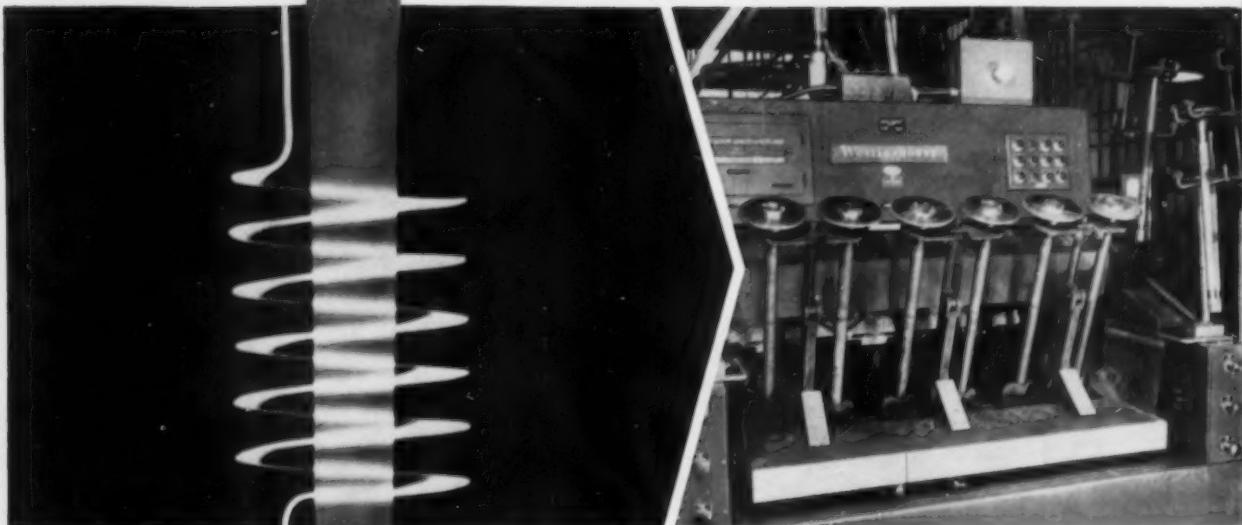
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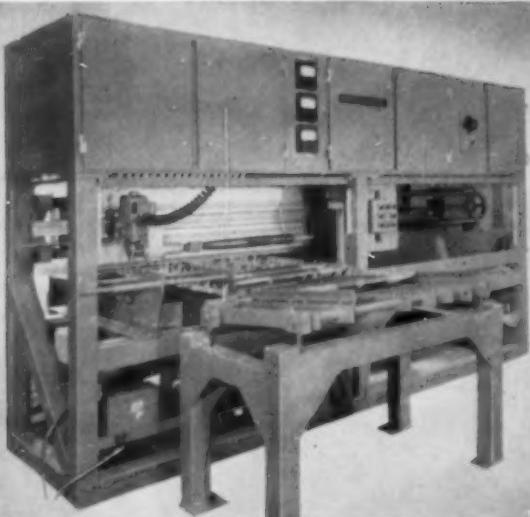


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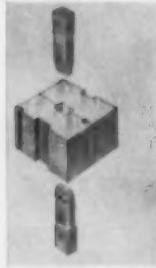
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Austenite Stability . . .

The Fe-Cr-C-N alloys have excellent room-temperature tensile properties when completely austenitic. At intermediate elevated temperatures, alloys containing ferrite, carbides and nitrides have tensile properties comparable to ferritic stainless steels. Tensile properties at 2000° F., where these alloys are completely austenitic, are at least equal to those of austenitic 25 Cr, 20 Ni steels.

S. T. Ross

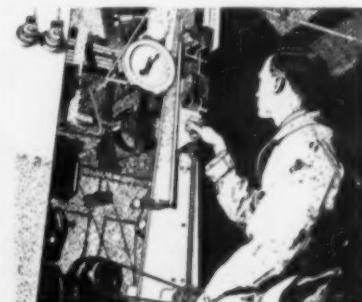
Effect of Environment on Creep-Rupture Properties

Digest of "Effect of Environment on Creep-Rupture Properties of Some Commercial Alloys", by Paul Shahinian. Preprint No. 34, 1956.

THE EFFECT of the atmosphere on the creep and rupture properties of a number of high-temperature alloys was investigated. Creep-rupture tests were conducted on both notched and unnotched specimens for times up to 500 hr. at temperatures ranging from 1100 to 1500° F. The effect of the environment on the properties of the alloys was analyzed in terms of rupture time, minimum creep rate, elongation at fracture and reduction in area, except for the notched specimens for which only rupture time was considered.

The longest rupture lives in most instances were found in an air atmosphere. Helium and vacuum produced the shortest rupture times. In several instances where the test atmosphere contained small amounts of impurities, the rupture life was greater than in air.

The minimum creep rate was usually lowest for the alloys in air. No definite relationship was evident for



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Creep-Rupture . . .

the effect of the other atmospheres on the minimum creep rate. The ductility was greatest for tests in vacuum.

For the notched specimens it was found that in alloys of relatively low ductility, the notch increased the effects of the environment. Oxidizing atmospheres produced a greater notch strengthening than the inert atmospheres.

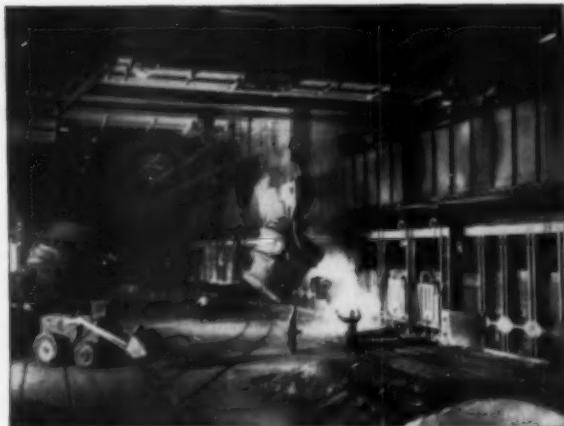
The mechanism of the strengthening effect of an oxidizing atmosphere may be attributed to a combination of several factors. Internal oxidation may strengthen the grain boundaries without producing any marked change in over-all hardness of the alloys, thus decreasing the creep rate. In addition, crack propagation may be inhibited by oxidation of the tip of the crack which decreases the effective tip radius. Other possible factors include surface oxide films which may inhibit the generation or migration of dislocations or strengthen the bulk material. The results obtained on the notched specimens support the view that the oxidation of the tip of an advancing crack may be the major factor in explaining the effect of environment on the creep properties. The investigation also shows that the notch sensitivity and environment must be considered together.

W. A. MORGAN

Aging Reactions in Superalloys

Digest of "Aging Reactions in Certain Super Alloys", by W. C. Hagel and H. J. Beattie Jr. Preprint No. 40, 1956.

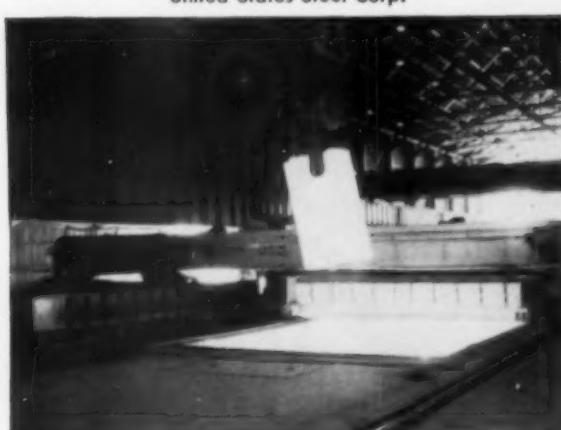
Few systematic studies have been made on the aging reactions in superalloys which precipitation harden by the formation of complex carbides, nitrides and other intermetallic compounds. For this reason the aging process in samples of hot worked and samples of arc-melted, hot worked and homogenized alloys of N-155, G-18 B and 15-15 N was investigated. The changes in properties and structures of the specimens were determined as a function of the solution treatment at 1800 to (Continued on p. 258)



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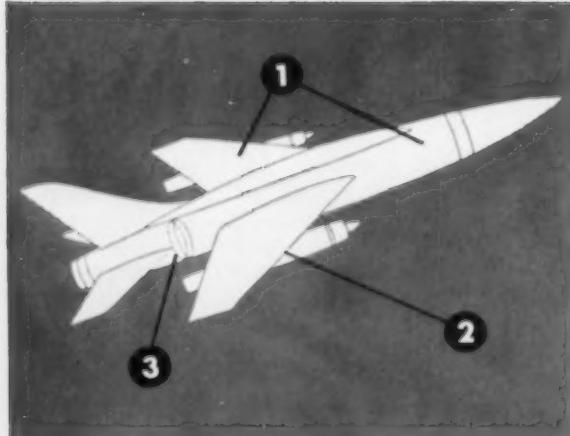
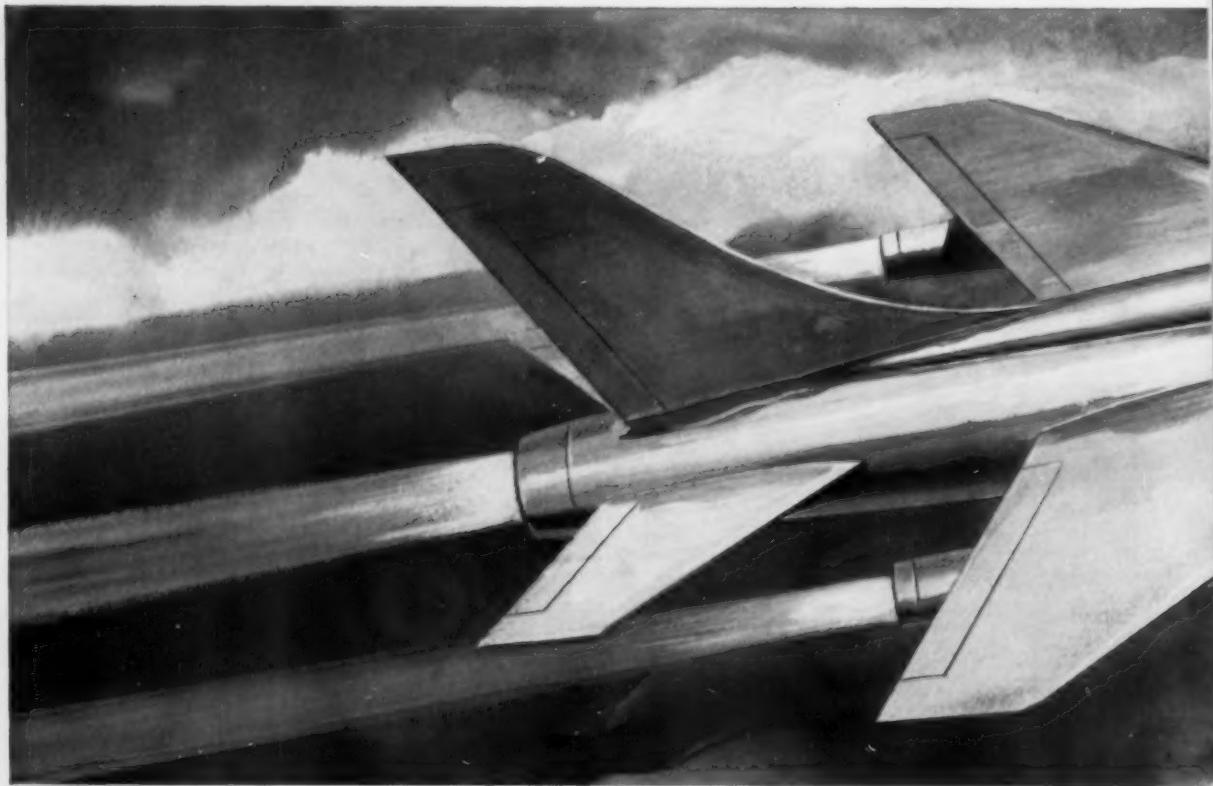
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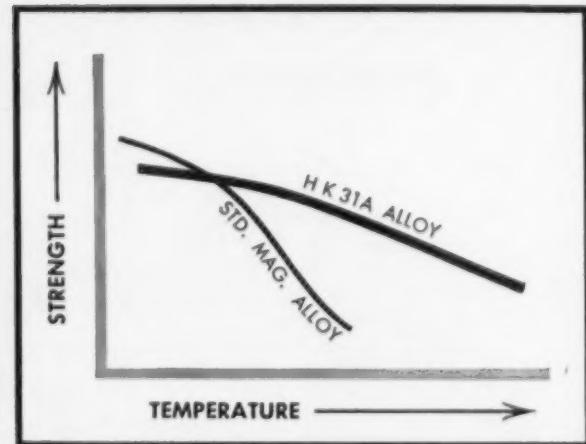
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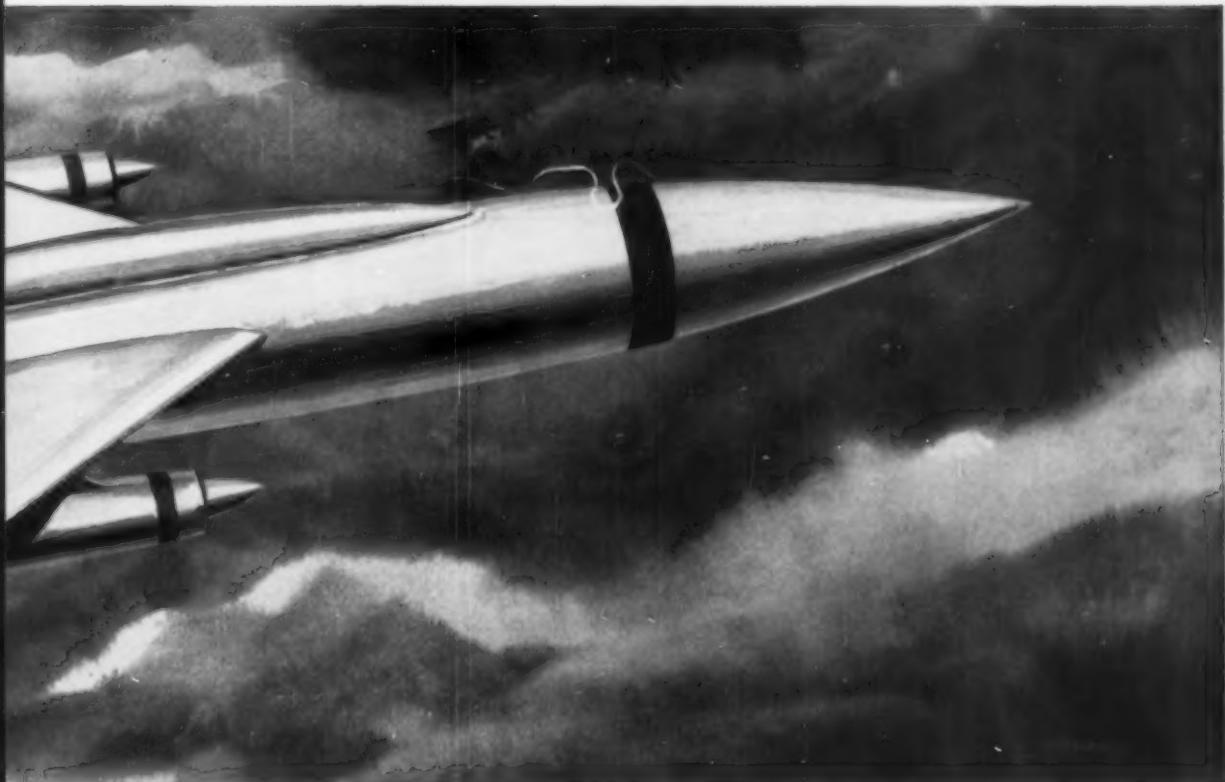


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These new magnesium alloys by Dow should be considered for your high temperature requirements. Contact your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Magnesium Sales Dept., MA 361D, Midland, Michigan.

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Aging . . .

2200° F. and the aging cycle at 1200 to 1600° F. for times up to 1000 hr.

Matrix lattice parameters of the alloys were measured with a back-reflection camera. Metallographic and electron microscope examinations were carried out on specimens electro-etched in 10% chromic acid. X-ray diffraction patterns of electrolytically extracted residues were ob-

tained from selected specimens to aid in the phase identifications.

Increasing the time at solution temperature up to 72 hr. caused only small additional changes in the hardness and matrix lattice parameters of the alloys compared to the effect of increasing temperature. In general the principal precipitating phases, $M_{23}C_6$ and M_6C , can be progressively dissolved after 8 hr. at 2200° F. leaving the stable columbium phases Cb (C, N).

Short-time aging at all temperatures causes the formation of a fine well dispersed transition phase whose composition may be M_4C_3 . Increasing time produces fine $M_{23}C_6$ -type carbide precipitation within the austenitic matrix and along twin and grain boundaries. At the same time, some grain-boundary segregation and transformation to (Mo, W)-rich M_6C takes place. Longer aging times promote coalescence of smaller carbides at grain boundaries and the formation of a low-parameter M_6C (M_6C'). When insufficient carbon remains to allow continued carbide precipitation, a blocky phase appears within segregated regions which gives X-ray evidence of a $Mg-Zn_2$ -type Laves phase.

There is a greater volume of Cb (C, N) and less M_6C at grain-boundary junctions in solution treated G-18 B. The structural trends are similar to N-155 except that lamellar M_6C' appears only after long times at 1400° F. In these two alloys, sufficient carbon is available to avoid the presence of Laves phase. With the 15-15 N alloys, less initial Cb (C, N) and fine M_6C can be seen and a small amount of $M_{23}C_6$ -type carbide precipitation occurs at grain boundaries. In the later stages of aging the Laves phase appears.

W. A. MORGAN



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New High-Temperature Alloy

Digest of "An Austenitic Alloy for High-Temperature Use", by R. W. Guard and T. A. Prater. © Preprint No. 32, 1956.

MOST austenitic alloys selected for use above 1500° F. derive their strength from precipitation hardening by carbides or Ni_3Al . Titanium, as Ni_3Ti , has been shown to be a relatively poor strengthener at high temperatures in nickel-base alloys. However, an earlier investigation indicated that in some cobalt-containing alloys it was possible to obtain satisfactory high-temperature properties in alloys containing titanium without aluminum. This paper describes investigations of the effects of composition, treatment and processing variables on a group of alloys containing molybdenum, tungsten and titanium.

(Continued on p. 262)



Your Source of Quality Heat Treating Materials and Personalized "On-the-job Service"

The next time you're faced with a difficult and costly heat treating problem, call in the man whose training and experience qualifies him as "the man with the answers": your local representative of the Park Chemical Company. As a representative of Park Chemical, for 45 years producers of a complete line of quality heat treating materials, your Park man will help you decide which materials and methods are best suited to smooth out your heat treating operations.

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Is steam treating an "unknown-quantity" to you?

If you work with metal . . . ferrous or non-ferrous . . . and haven't considered steam atmosphere heat treating for your product, you may find you've overlooked an unsuspected source of surprisingly substantial savings.

For in scores of plants it's becoming an outstanding cost-cutter on parts made of high speed steel, powdered iron, carbon steel, grey iron, brass aluminum and beryllium copper. And its advantages are almost as numerous as the materials being steam treated.

On high speed cutting tools, for instance, it keeps tools sharp longer.

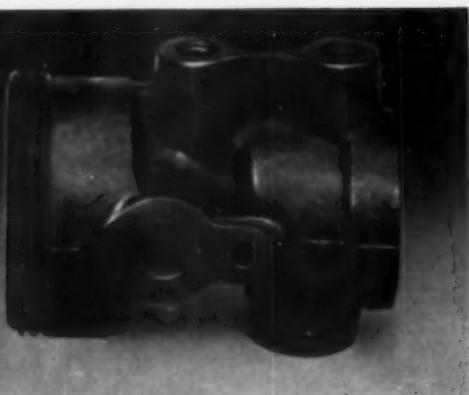
On powdered iron, compressive strength and hardness increase appreciably. On carbon steel it gives a uniform, attractive, blue-black finish. On grey iron it seals against porosity and gives a high degree of corrosion resistance. On non-ferrous parts it produces scale-free work ready for bright dip or often for use "as-is."

Here and on the opposite page are just four examples to illustrate our point. If you want others . . . or details on any of these . . . or want us to help investigate possible savings you can make, just phone your nearest L&N office or write us at 4927 Stenton Ave., Phila. 44, Pa. Catalog TD2-620(1) tells all about it, too; we'll be glad to send you a copy.

LEEDS  **NORTHRUP**
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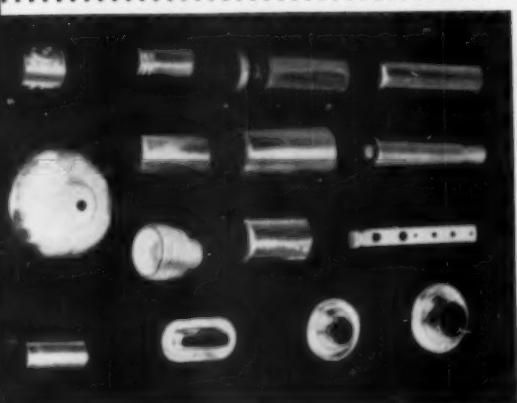


**See an operating demonstration at Booth 1129
at the Metal Show in Cleveland October 8 to 12.**



Replaces Cadmium Plating . . . These grey cast iron valve bodies are used in the pneumatically operated sanders that deliver sand for improved traction under the wheels of trains, trolleys and trucks. Their manufacturer had a double-barreled problem . . . porosity in the castings was causing excessive rejects . . . expensive cadmium plating was necessary to prevent corrosion in service.

Steam treating has solved both problems in one operation. Rejects due to porosity have been eliminated, and many valves previously rejected have been salvaged. Cadmium plating has been eliminated entirely because exhaustive salt spray tests showed the steam-treated finish had a higher resistance to corrosion.



Cuts Expensive Pickling Costs . . . Non-ferrous lipstick tubes and other cosmetic containers made by a large Canadian manufacturer must be annealed before finishing operations can be performed. Scale was a problem. If left on, it ruined tools and dies . . . removing it meant expensive, messy pickling.

The solution was found when sample parts were annealed by the steam Homo* method. When this method was adopted as an integral part of the production line, pickling was eliminated. Subsequent figures from the cost-accounting department showed that eliminating this operation reduced annealing cost by 53 percent.



Puts "Extra-Life" In Cutting Tools . . . A machinery manufacturer faced a tough problem when specifications called for milling a 0.250 inch wide key-way slot into a piece of 4140 cold-rolled bar stock which was heat treated to a hardness of Rc 34 to 38. In addition, tolerances were tight . . . ± 0.001 inch . . . with sides perfectly square.

The first high-speed steel tools used produced only four cuts and could not be resharpened because of the close tolerance. Hard-chroming the same tools improved cutter life to about 11 pieces per tool. Carbide tools held up for from 11 to 14 pieces. The next move was steam treating experimental batches of tools in an L&N furnace. The first batch averaged 100 parts per cutter, a second batch, 60 to 70 and a third lot, 100 to 125.



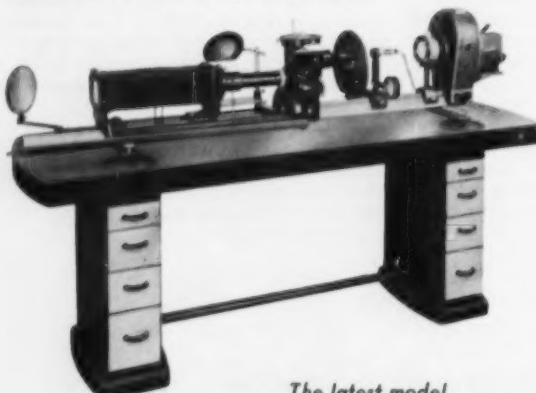
Raises "psi" of Powdered Iron Parts . . . Although many parts made of powdered iron function satisfactorily in the as-sintered condition, there are others where an increase in hardness and compressive strength is an advantage.

This is particularly true of such parts as the steam-treated gears, cams, etc., shown at left, where additional strength is needed on critical bearing surfaces. The shock-absorber piston in the center, for instance, presented a real problem . . . how to meet psi specifications for the thin-section flange around the outer edge. Steam treating proved a cheap, practical solution. Tests showed compressive strength of the flange increased from 1200 to 1400 psi. In addition, the parts, when oil dipped, had a pleasing uniform, blue-black color and high corrosion resistance.

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New Alloy . . .

The precipitate present in the best alloys of the series, at least in the overaged condition, was identified as Ni₃Ti. The structure of this compound indicates it would probably take little molybdenum or tungsten into solution. At lower temperatures (1350° F.), the carbon in solution is precipitated as alloy carbides. It was found that the molybdenum, tungsten and iron content of the solid solution matrix were important in controlling the aging process.

Composition is the most important factor in determining rupture strength. Alloys with small amounts of iron resist loss in rupture life due to overaging much better than the alloys containing 20% iron. Iron content had little effect on the rupture ductility, however. Molybdenum and tungsten show similar beneficial effects on rupture ductility and rupture life. The effect of variations of titanium content or carbon content in the range of 0.4 to 1.0% is small.

The single alloy finally chosen for intensive investigation of the effects of processing variables contained 29% Ni, 19.9% Cr, 13% Fe, 6.8% W, 4.1% Ti, 3.9% Co and 0.20% C. Although it had been indicated by early testing that sufficient ductility could probably be obtained in any of the alloys, certain heat treatments resulted in low elongation and short fatigue life. Although the solution treating temperature was of greatest significance in determining the amount of ductility obtained during testing, aging temperature also had some effect. Aging treatment which produced the largest increase in rupture life and hardness resulted in low ductility. A high aging temperature (1650° F.) resulted in a structure which appears to be overaged but which showed a marked increase in tensile ductility with little sacrifice in rupture or tensile strength. The best heat treatment appears to be solution at 2100° F. and aging at 1650° F.

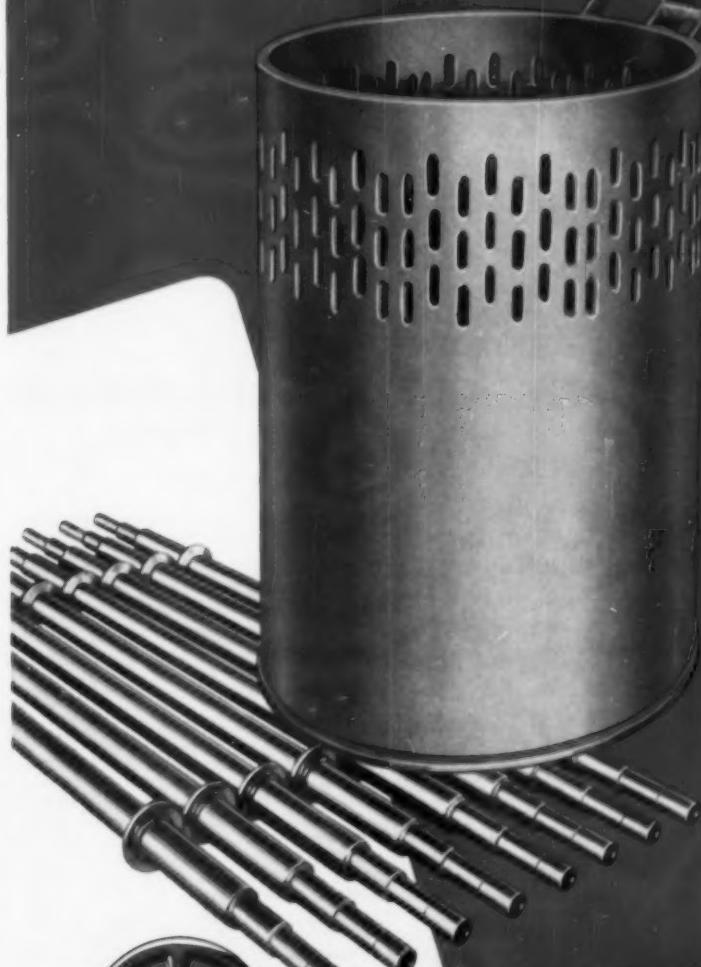
Mechanical properties of the alloy when solution treated and aged, and rupture lives and ductilities of ten heats of the alloy under various testing conditions are included in tabular and graphical form. At 1600° F. its 1000-hr. rupture strength is 15,500 psi.

E. S. RIDER

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HEAT AND CORROSION *Alloys*

CASTINGS FOR HIGH
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Our engineers need only complete details about the casting requirements of your heat treating operation to design and produce Fahrite castings with the correct characteristics to meet your exact operating conditions. A few of the many types of Fahrite castings made by Ohio Steel are:

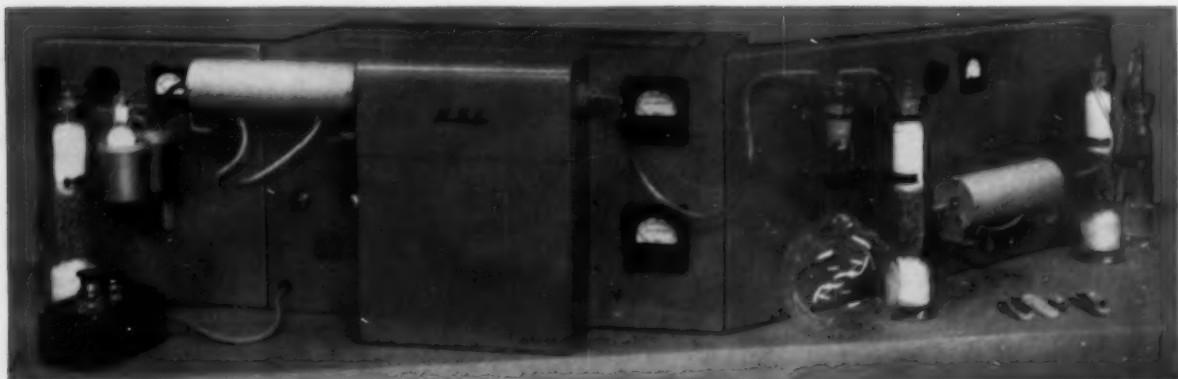
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"The most valuable information for the heat treater... is accurate, reliable data to show him how to adjust furnace atmosphere."

That is one of the most significant quotes from papers presented at the recent National Metal Congress. And the practical answer on control of furnace atmospheres is to determine carbon potential by reading dewpoints in each furnace zone with an Alnor Dewpointer.

With the Dewpointer You Can:

1. **Read Each Furnace Zone.** With the portable, self-contained Dewpointer, you can readily check each zone in the furnace... instantly detect restricted flow of atmosphere, leaky furnace seals or transient moisture and air from the quench tank, and air carried into the furnace with the charge.

2. **Get Accurate Data.** Only the Dewpointer gives you controlled testing conditions... indications take place in enclosed chamber. Dew or fog is suspended in air as sunbeams—not on a polished surface. This gives you the greater accuracy, faster readings required for critical atmosphere control.

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Eliminate Guesswork

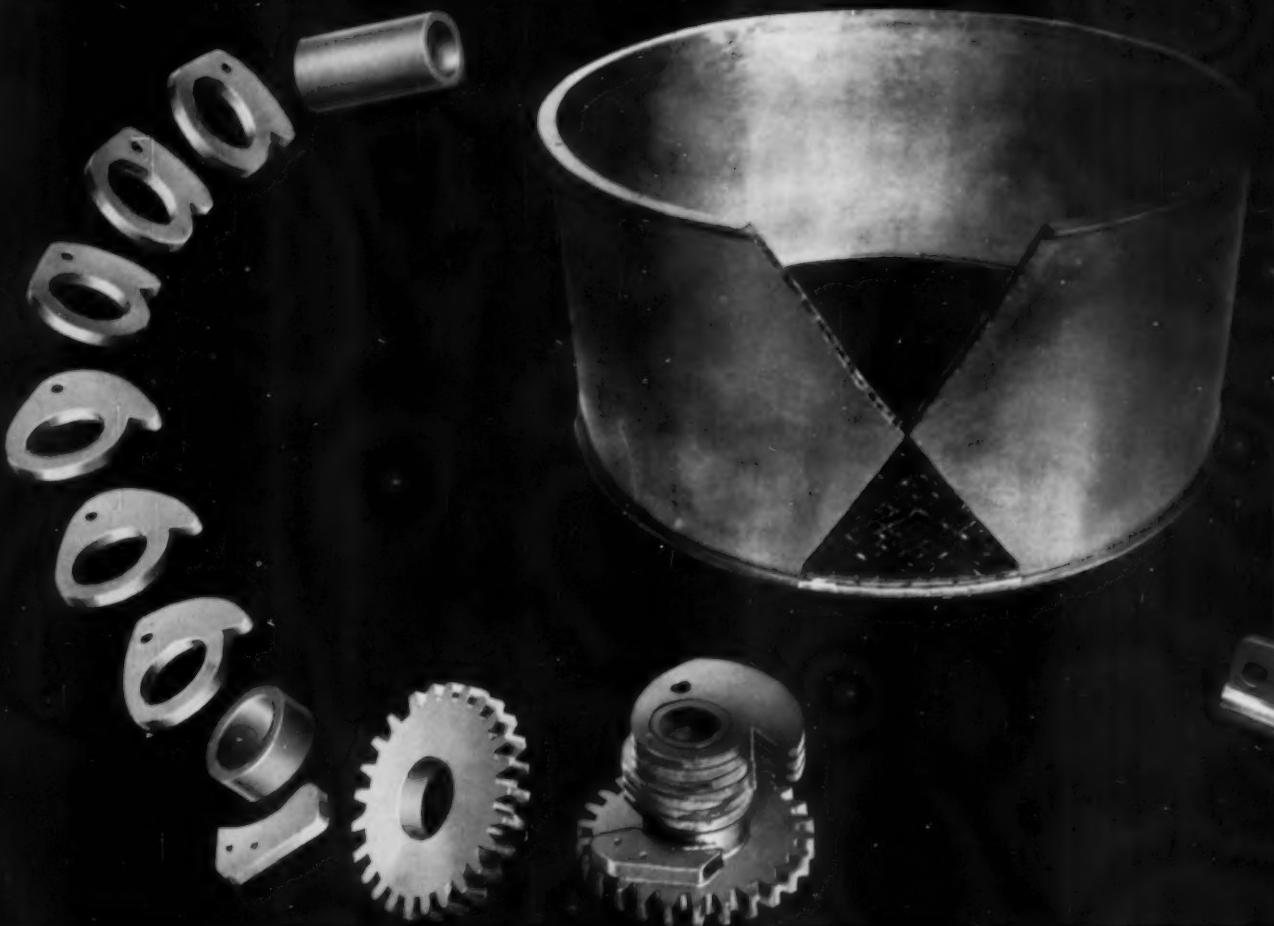
You actually see the dew or fog suspended in a test chamber—no guessing as to when fog starts to form on polished surface. Find out why the Dewpointer is so widely used for accurate atmosphere control. Send for your copy of new illustrated Dewpointer Bulletin.



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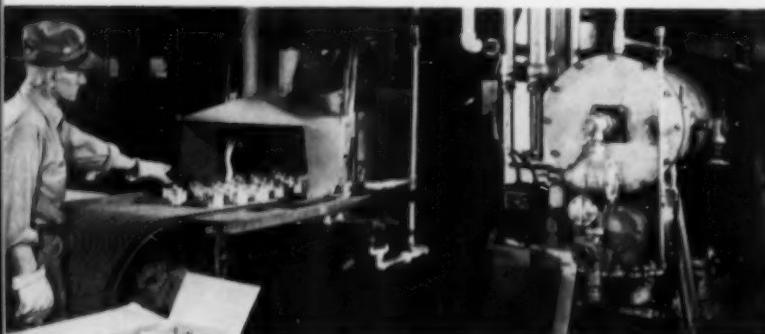
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Chicago 10, Illinois

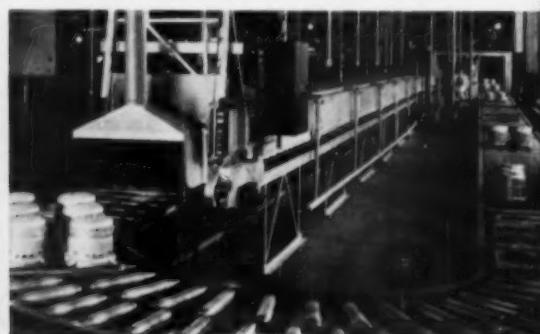


Versatility of furnace brazing is shown in these applications. Complex assemblies like the cam-and-gear cluster on the left can be fabricated from punched laminations brazed securely in a General Electric mesh-belt furnace. Required contours are obtained without expensive machining from solid stock.

Thin sections can be joined to heavy sections to produce light-weight rigid structures without sacrificing strength or inducing local distortion. Honeycomb structure at top center weighs about one fourth as much as solid assembly of same rigidity. It is typical of design improvements made possible by brazing in General Electric furnaces.



Continuous production of small parts in this General Electric mesh-belt furnace is carried out by loading assemblies directly on the belt. Protective atmosphere equipment, at right, eliminates need for flux in most cases, keeps parts clean enough to be passed directly from the furnace, without cleaning or pickling.



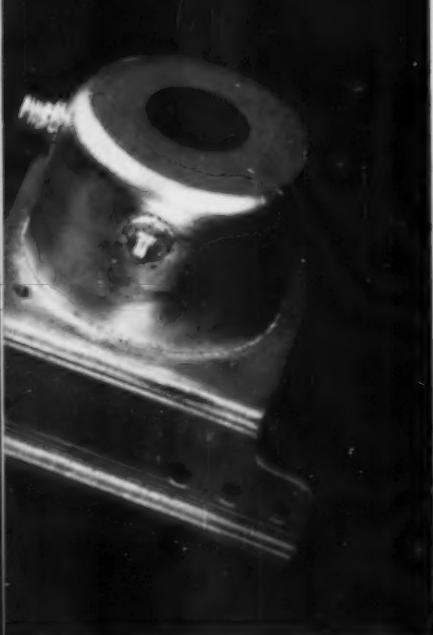
Automatic charging, and discharging and return conveyors of this General Electric roller-hearth furnace make it almost self-operating, reduces handling costs. G-E roller-hearth furnaces handle heavy assemblies and are well suited for automated lines.

**GENERAL ELECTRIC SELLS
A COMPLETE LINE OF
HEAT PROCESSING EQUIPMENT**

FURNACES • METAL-SHEATH • INDUCTION



Produce Complex Assemblies Faster and at Less Cost with General Electric Furnace Brazing



Two or more metals can be joined, as in the bellows housing shown above. The steel flange is furnace-brazed to a brass shell, using preplaced rings of silver brazing alloy. The desirable qualities of each metal are retained.



Development work is done in this General Electric box furnace, which could also be used for job-lot production. Low in first cost, General Electric box furnaces need little maintenance.

General Electric furnace brazing speeds production of really "tough" assemblies—and often does it at less cost than you can do it by your present methods.

For example, here are three types of work where you can improve production with furnace brazing.

You can make complex assemblies from already formed components, and save both material and machine costs.

You can make assemblies of two or more different alloys without changing the desirable characteristics of either.

You can join thin sections to heavy sections without sacrificing strength or inducing local distortion.

These characteristics of furnace brazing can be used in a number of widely different production setups. And General Electric's complete line of furnaces and associated equipment lets you pick the proper furnace to introduce furnace brazing into your particular setup—economically, efficiently.

Cost reductions are typical with furnace brazing because labor content per assembly goes down while output goes up. Waste is reduced since assemblies can be built up of components instead of being

machined from solid stock. Uniformity of results frequently leads to reduced inspection costs.

Improved products are the rule with furnace brazing. Life of assemblies is increased because joints have high strength, resist vibration and impact, and are uniformly tight. Assemblies show little or no distortion, since they are free from localized strains. They present a good finished appearance without afterwork because the brazing alloy forms neat fillets. Also protective furnace atmospheres eliminate formation of oxides and do away with the need for flux in most cases.

Increased production over other joining methods is possible, since many joints can be brazed simultaneously. Furnace brazing is adaptable to continuous production, with increasing output.

For a careful analysis of your furnace brazing needs call your General Electric Heating Specialist. Ask him to show you how you can benefit by using furnace brazing. You can reach him at your local General Electric Apparatus Sales Office. If you prefer, send in coupon below for bulletins describing furnace brazing operations and equipment.

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 Electric Furnace Brazing, GER-106
 Furnace Brazing of Machine Parts, GER-339

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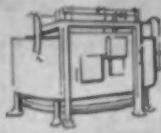
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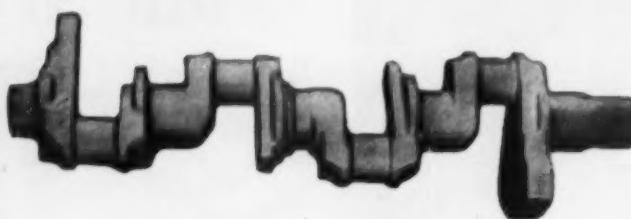
Electronic Induction

whether
you
think
in terms
of

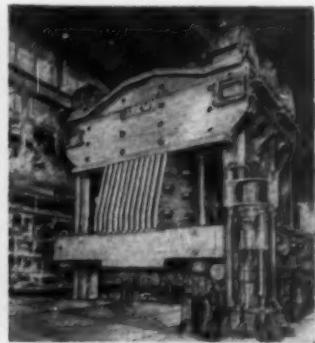
Horsepower

or

Thrust



The crankshaft is the backbone of the piston-type engine. Illustrated above is the crankshaft forging for the most powerful piston-type aircraft engine ever produced.



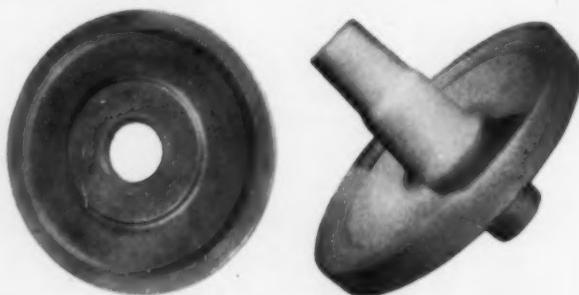
The history of Wyman-Gordon's contribution to aircraft progress dates from the inception of the "flying machine".

The jet age is now calling on the unparalleled resources of Wyman-Gordon, which include the widest range of hammer and press equipment and the greatest technical know-how in the industry.

Larger and more intricate forgings than heretofore available of aluminum and magnesium are being produced on presses up to 50,000 ton capacity, and giant hammers are fulfilling the growing need for forgings of titanium, high density materials or so-called super alloys.

Now, as for nearly 75 years, there is no substitute for Wyman-Gordon experience and ability for — Keeping Ahead of Progress.

At the bottom left is a turbine disc forging made from high density heat resisting alloy, and next to it is a titanium compressor wheel forging for two of the most powerful jet engines yet produced.



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6 reasons for checking your Commercial Heat Treater First

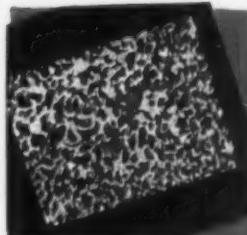
HE PROVIDES . . .

1



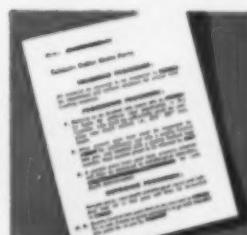
Guidance in Steel Selection and Design

2



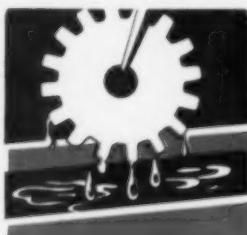
Metallurgical Understanding of Metal Properties

3



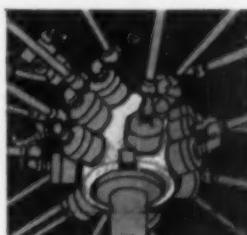
Assistance in Proper Preparation of Parts for Heat Treating

4



Knowledge through Experience of the Right Heat Treat for the Job

5



Extensive array of Equipment and Facilities

6



Final laboratory and non-destructive Testing

Whenever your production requirements for a new product or the redesign or improvement of an old one mean the installation or expansion of heat treating activities, it will pay you to check with your Commercial heat treater before tackling the job yourself.

The 6 basic reasons for this are shown above. Remember the Commercial Heat Treater has the skill, the experience, the equipment;—all under one roof ready to serve you.

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Kansas City 8, Missouri

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New England Metallurgical Corp.,
South Boston 27, Massachusetts

Poulo Products Company,
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Pittsburgh Commercial Heat Treating
Co.,
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The Queen City Steel Treating Co.,
Cincinnati 25, Ohio

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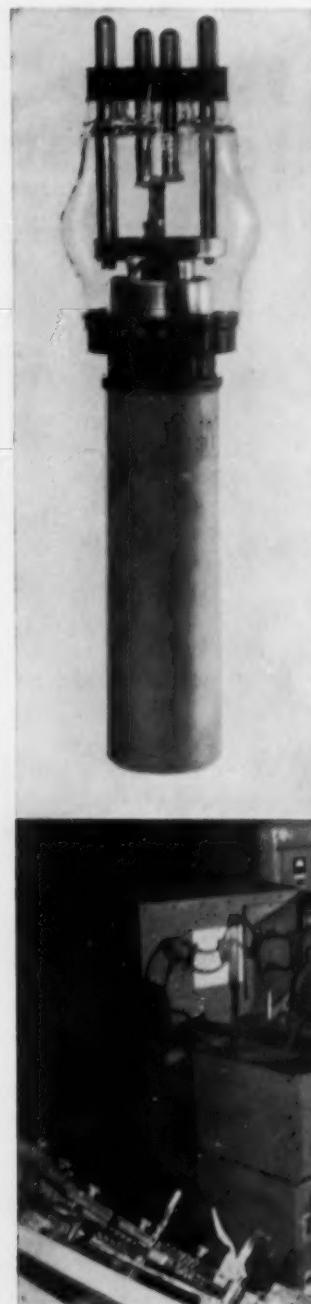
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Detroit 10, Michigan

Syracuse Heat Treating Corp.,
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Winton Heat Treating Company,
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At Wright Aeronautical Division
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COMPLEX BRAZING

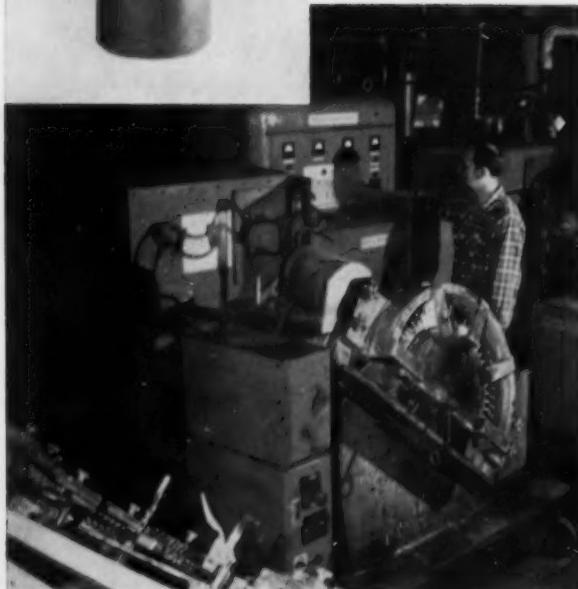
is sure and quick
with R-F Induction Heat
using

Machlett ML-5668*

INDUSTRIAL OSCILLATOR TRIODES

Each Curtiss-Wright J-65 turbojet engine uses 544 shrouded stator blades. Each blade must be positioned accurately and without physical distortion. Although brazing a single blade to the shroud ring is not difficult, it is quite a feat to perform rapid multi-blade brazing on a sustained production basis. Curtiss-Wright does just this in each of its three induction heating stations, each powered by two Machlett ML-5668 induction heater triodes.

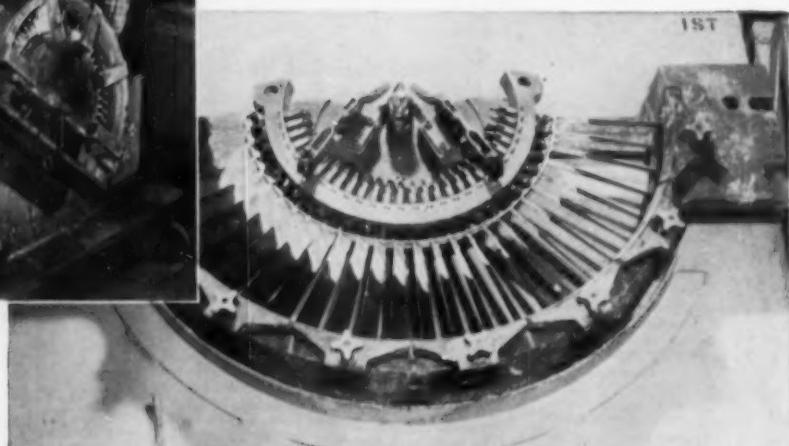
*Machlett induction heater triodes are original equipment in over 75% of the induction heating equipment models now available in the 5kW to 100kW power output range. . . Proof enough of Machlett electron tube quality and performance!



Top - ML-5668 Induction Heater Triode

Center - One of three induction heating stations used for production brazing of stator assemblies used in Curtiss-Wright's J-65 turbojet engine.

Bottom - Stator assembling jig for Curtiss-Wright's J-65 turbojet engine.

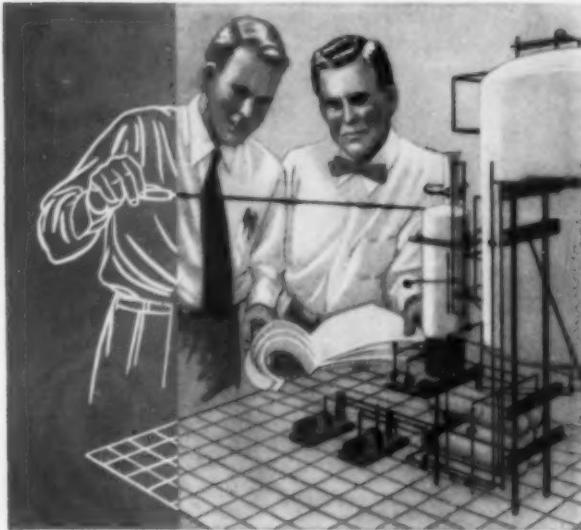


***ML-5668** Original Machlett electron tube design; heavy duty triode replacement for old design, light construction type 892 tube.

MACHLETT

FIRST IN INDUSTRIAL ELECTRON TUBES

MACHLETT LABORATORIES INC.
Springdale, Connecticut



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Ask P & G About Your Real Future

Engineering models like the one above play a vital part in providing Procter & Gamble engineers with a three-dimensional look at the future.

Naturally you can't build a scale model of your own future, but you can plan closely a future that will combine your technical skills with the greatest professional and personal opportunities. And in its Cincinnati engineering staffs for domestic and overseas activities P & G is ready to help you realize your engineering career plans in the following fields:

- Automatic Machinery • Chemical Process Equipment • Power Generation and Distribution
- Instrumentation and Control • Building Design • Metallurgy
- Construction Management

Procter & Gamble offers you:

- An immediate, challenging engineering role with one of the nation's leading manufacturers of soaps, detergents, drug products, food products and chemical specialties.
- A program of career development custom-tailored for your interests—whether they are of a technical, administrative or managerial nature.
- The opportunity to progress rapidly with a company that has doubled its business volume every 10 years since 1900. Over half of the company's total present business in household products is in brands not on the market 10 years ago. P & G has been cited by the American Institute of Management consistently as one of the nation's best-managed companies.

IF . . .

Your background qualifies you for any of the above opportunities . . .

You were graduated with an engineering degree within the last 10 years . . .

DISCOVER YOUR REAL FUTURE
IN ENGINEERING AT P & G
BY FILLING OUT AND MAILING
THE COUPON AT THE RIGHT

Mr. J. E. Gale
Engineering Division
Procter & Gamble
Cincinnati 17, Ohio

Dear Mr. Gale:

I would like to know more about my *real future* in engineering with Procter & Gamble. Please send me your four-color brochure "Future for Engineers and Chemists" and a personal data sheet.

Name _____

Address _____

Whatever your furnace needs for control—

There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose **ElectronIK Strip Chart Controllers** for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.



Choose **ElectronIK Circular Chart Controllers** for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.



Note: the basic components of all *ElectronIK* models are interchangeable . . . to simplify and speed up service.

Choose **ElectronIK Circular Scale Controllers** where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Note: all *ElectronIK* models are available in both Standard and Precision Series.

Choose **Pyr-O-Vane Controllers** where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument . . . also available with pulse-type time proportioning action, in both vertical and horizontal models.



Choose the **Protect-O-Vane Safety Cut-Off** for simple, dependable excess temperature protection . . . can be used with any temperature control to prevent furnace shut downs and loss of production.



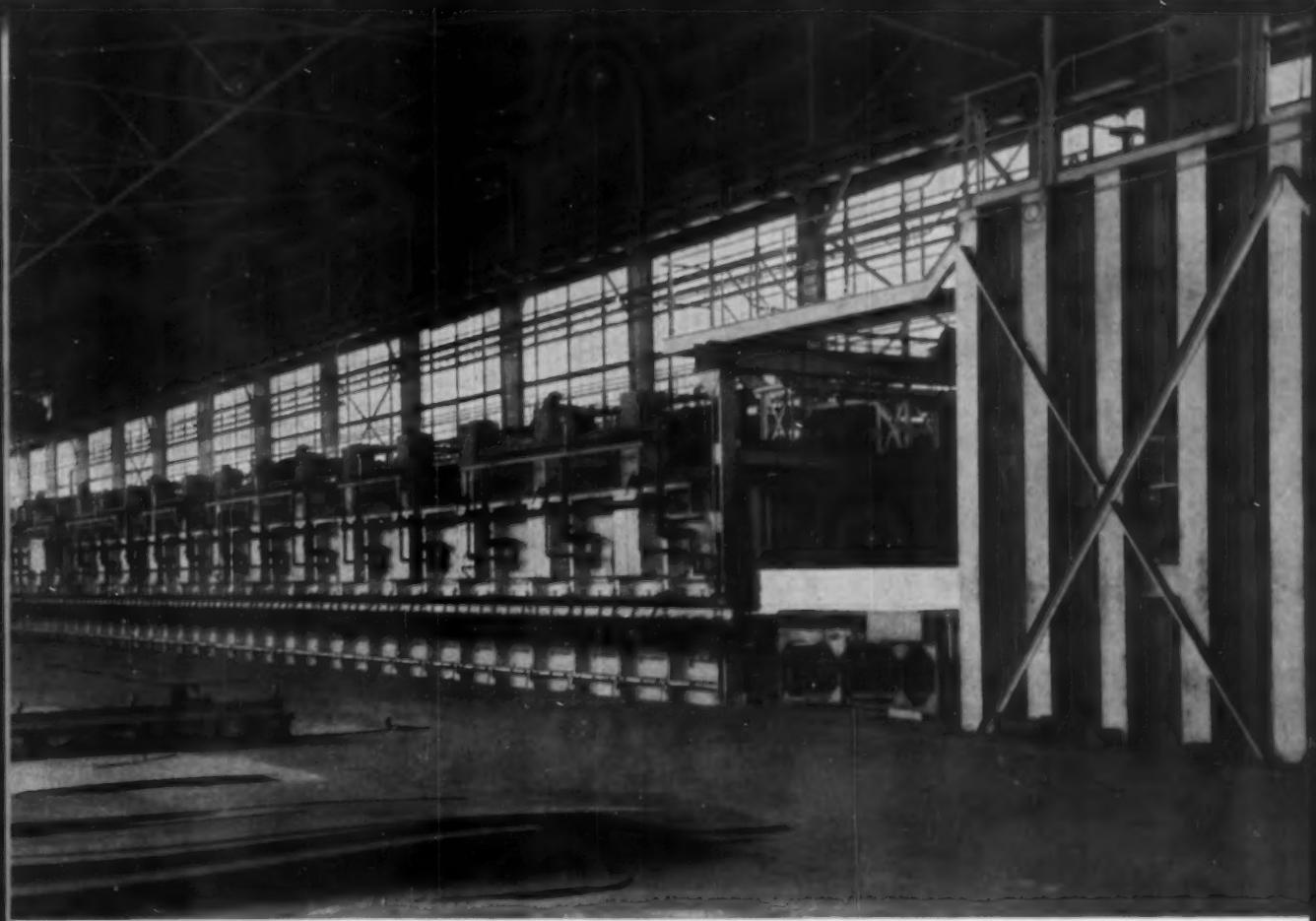
And . . . for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

354 feet from loading end to quench press, this continuous heat-treating line at Lukens Steel Co. processes wide steel plate quicker, more economically than ever before. Feature of the line is a Drexler furnace, controlled by *ElectronIK Air-O-Line* instruments.

130" steel plate
heat treated to
close temperature



In the control pulpit, the operator can watch each zone temperature . . . clearly displayed on the circular chart *ElectronIK* controllers on the instrument panel.



limits in Lukens' new 202' furnace

STAINLESS steel plate up to 130 inches wide, 1 inch thick and 40 feet long is heat treated in a new line now operating at Lukens Steel Company, Coatesville, Pa. Designed by the Drever Co., Philadelphia, the line—longer than a football field—handles austenitic stainless alloy plates.

To handle the work that Lukens produces, the furnace was designed for accurate, flexible temperature control. 90 Bloom burners, firing either natural gas or No. 2 oil, supply heat under control of a battery of *ElectroniK* instruments. Through their *Air-O-Line* pneumatic control systems, these instruments regulate heat input to each furnace zone. They hold temperatures at the values set by the operator . . . throughout working ranges between 900 and 2000°F.

Close temperature control of this big furnace is the

result of good furnace design . . . and top performance by instrumentation. It's the kind of job for which *ElectroniK* controllers have been chosen in thousands of metalworking and metal producing plants for more than a decade. Whether you're planning new equipment or modernizing, be sure that you select *ElectroniK* instrumentation . . . to be sure of the best in controls, made by the world's largest manufacturer of controls.

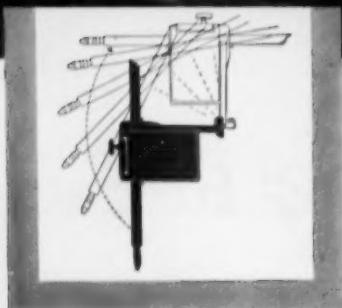
Let's talk over your specific control problems. Just call your local Honeywell field engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

• REFERENCE DATA: Write for Catalog 1531, "ElectroniK Controllers" and for Price List 56-1, "Furnace and Oven Controls."



MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



► New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

Airco introduces New Automatic Heliweld Head for long-run production welding

The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours — aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

- **Versatility** — unit provides good arc voltage control using either argon or helium shielding gases or mixture of both.
- **Adaptability** — the head can be operated at all angles from the horizontal to the vertical (normal) position.

The maximum raise-lower distance of the electrode holder is a full 16".

- **Flexibility** — the assembly can be used for AC or DC welding, with or without filler wire. Electrode diameters range from .020 to $\frac{1}{8}$ ".

The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .



Offices in most
principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N.Y.

On the west coast —
Air Reduction Pacific Company

Internationally —
Airco Company International

In Cuba —
Cuban Air Products Corporation

In Canada —
Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: AIRCO — Industrial gases, welding and cutting equipment, and acetylenic chemicals • PURECO — carbon dioxide, liquid-solid ("DRY-ICE") • OHIO — medical gases and hospital equipment • NATIONAL CARBIDE — pipeline acetylene and calcium carbide • COLTON — polyvinyl acetates, alcohols, and other synthetic resins.



AT THE HUB OF INDUSTRY IN THE HEART OF AMERICA

Here at Fahr alloy we believe in giving service as well as manufacturing top quality heat and corrosion resisting castings. In fact, service is a keystone upon which our business has grown over almost a quarter of a century. Sitting here at the hub of industry in the heart of America we're never more than a few hours away from you at most. No matter what your problem may be if a heat and corrosion resisting casting is involved, you'll find the solution at Fahr alloy.

Try us and see for yourself.

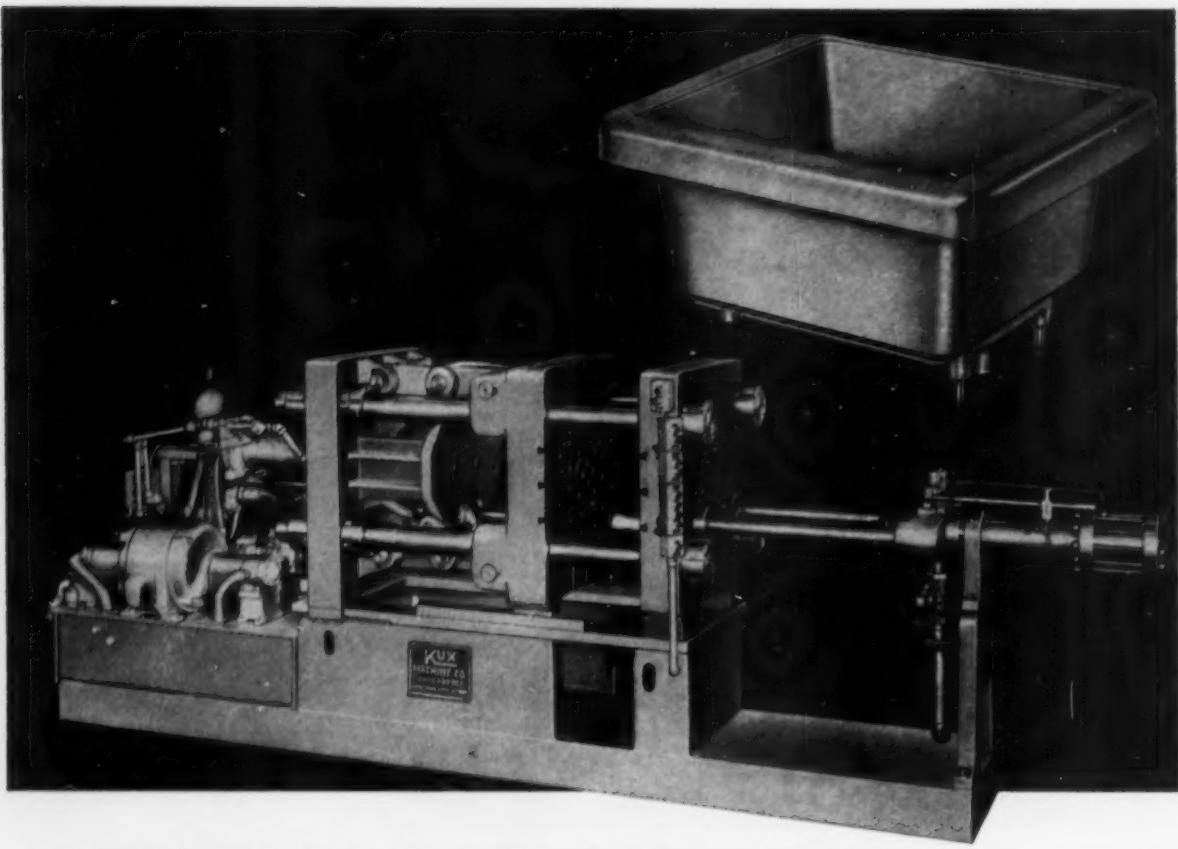


Fahr alloy serves the nation and the nation's leading industries with heat and corrosion resisting castings.

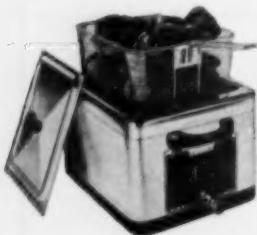
- AIRCRAFT
- APPLIANCE MANUFACTURERS
- ARMED FORCES
- AUTOMOTIVE
- CHEMICAL
- DRUG
- FARM EQUIPMENT
- FOOD PROCESSING EQUIPMENT
- GENERAL MANUFACTURING
- PUMP MANUFACTURERS
- STEEL

THE FAHRALLOY CO.

150th & Lexington Ave. — Harvey, Illinois
In Canada — Fahr alloy Canada, Ltd., Orillia, Ontario



to get hardware finish quality castings with cast-in heating elements **EASTERN METAL PRODUCTS** chose...



KUX DIE CASTING MACHINES

for the Alcamatic Cooker and Deep Fry

"The die-cast well is the heart of our ALCAMATIC Cooker and Deep Fry and naturally must be of top-quality construction," says Mr. Seymour Troy, executive vice-president of Eastern Metal Products Corp., Tuckahoe, N.Y.

"The use of KUX machines (3 in the Forth Smith, Ark., plant and 4 in our Tuckahoe factory), plus our own production processing, enables us to provide the finest aluminum well, making the product an excellent working unit as well as an attractive appliance.

"KUX machines make the difficult problem of cast-in Calrod heating elements easy," Mr. Troy says, "plus cutting our production costs considerably."

"The hardware finish quality castings provided by KUX machines eliminates many polishing and finishing operations and leaves the fry well easy for the housewife to clean."

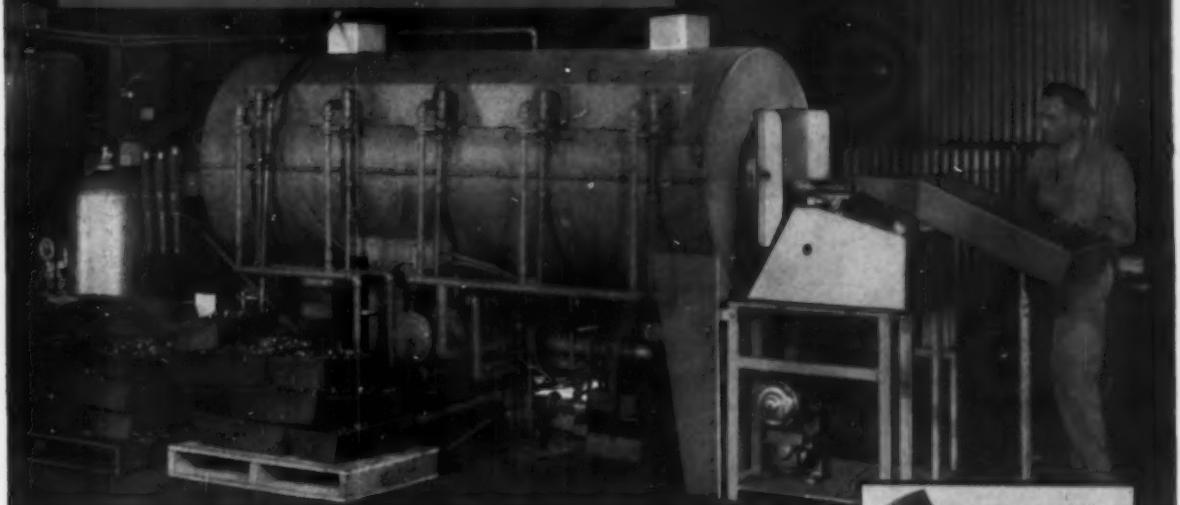
For the manufacture of electrical appliances requiring dense hardware finish quality castings, KUX die casting machines are unexcelled. Write for our NEW illustrated catalog.

MODEL HP-37 ILLUSTRATED

*Hydraulically operated die casting machine
for production of aluminum castings.*

KUX MACHINE CO. 6725 NORTH RIDGE AVENUE • CHICAGO 26, ILLINOIS

"second helpings" for satisfied customers...



"OUTSTANDING PERFORMANCE"

THAT'S WHY VALLEY HEAT TREATING CO.

*Pacific-built furnace!

When a heat treating customer is willing to pay a premium price to get the quality he needs, you can be pretty sure he can't afford many rejects.

That was the case with one of Valley Heat Treating Company's customers who selected them because their rigid specifications could be met without expensive rejects. The amazing part of the story is that Valley was actually able to *lower their cost by 15% while they still met these specifications!*

Much of the credit must go to Valley's new Pacific Gas-fired Shaker Hearth Furnace. This furnace provided a combination of fast and economical operation with extremely uniform control of the work.

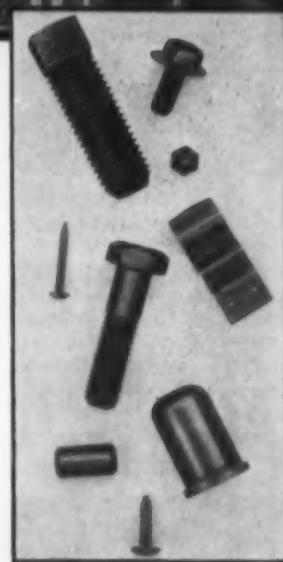
Rated at 500 pounds per hour, this new Pacific Furnace is used for Carbo-nitriding and scale-free neutral hardening. It permits maximum

hardness of all parts, and the 14" wide Inconel hearth with Pacific's exclusive shaker design allows a wide variety of work to be handled without damage to the parts.

According to Valley, their work comes out exceptionally clean, requiring only washing before delivery, and case depth is easily controlled due to Pacific's uniform-heating burner design.

This profitable performance is the reason Valley has installed two different types of Pacific Furnace, and has recently ordered a third!

For more information on a Pacific Furnace for your heat treating job, whatever it is, write today!



Typical of the wide range of parts handled in this furnace.



INDUSTRIAL
HEAT TREATING
EQUIPMENT

PACIFIC
SCIENTIFIC
COMPANY

© TRADE MARK

LOS ANGELES
SAN FRANCISCO
SEATTLE
PORTLAND, OREGON
ARLINGTON, TEXAS



GAS-FIRED
OR
ELECTRIC



PACIFIC SCIENTIFIC CO. P.O. Box 22019, Los Angeles, California

Please send me
bulletins and
specifications
on a Pacific
Furnace for:

(type of work)

Name _____

Company _____

Address _____

City _____ State _____

BRISTOL'S Instrumentation News

• News of instrumentation and automatic control in industrial heating and metallurgy •

New instruments pass tough "field" tests at home



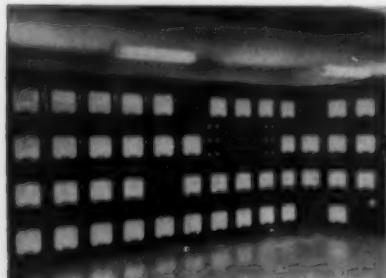
HEAT-TREATING FURNACES (above) for Bristol's own socket screws give Bristol instruments (left) a thorough workout.

New Bristol instruments for metal-treating operations have a ready-made proving ground in Bristol's own socket screw manufacturing division.

Bristol instruments monitor and automatically control every phase of the Socket Screw Division's metal treatment—including a variety of continuous and batch-type furnaces, salt-baths, and tinning and degreasing operations for specialty products.

Completely automatic control assures highest quality and uniformity for Bristol socket screw products. New instruments get grueling "field" tests before they're released for general distribution. And, last but not least, visitors to the Waterbury plant can see Bristol instruments under actual load conditions.

Drop in, when you're in the New England area, and watch these precision instruments at work!



Telemetering helps control steel plant fuel

This Bristol telemetering installation helps U. S. Steel, Gary, Indiana, get the highest steel production with the lowest possible fuel cost.

The panel shows the amount of coke-oven and blast-furnace gas used throughout the plant as well as gas pressures at critical locations. With this complete supply and demand information at their fingertips, fuel dispatchers can control distribution for maximum efficiency and economy.

Precision rolling mill produces steel tapes 0.000125" thick

This precision cold-strip mill at The Arnold Engineering Company, Marengo, Illinois, rolls ultra-thin high-permeability strips for magnetic cores. The core strips may be as thin as 0.000125" and must be held to extremely close tolerances. To achieve the necessary precision, AccuRay gauges—employing Bristol Dynamaster recorders—measure thickness of material on both sides of the rolling mill. The AccuRay equipment is built by Industrial Nucleonics, Columbus, Ohio.



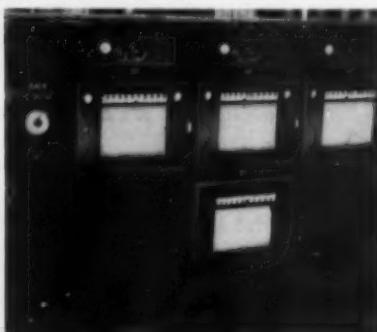
New control techniques cut fuel bills for metals

In 20 years, fuel required for ingot heating has dropped 50 to 60%.

A big share of the credit for this fuel economy goes to automatic control and instrumentation techniques developed recently. These new techniques, with better, faster, more accurate sensing and response, have chalked up significant savings, not only in fuel, but also in fixed charges, rolling time, and maintenance costs.

Probably most important for big savings is control of furnace temperature and atmosphere. Furnace pressure may be regulated by positioning the stack damper. Fuel-air ratio can be controlled by a valve in the air line. Air requirements for combined fuels may be totalized for better distribution of fuel throughout the plant.

Proper temperature-time sequences or "time cycles" also rack up big savings. Step heating sequences, differing for various metal ingots, no longer need be programmed by rule of thumb. Instead, any predetermined sequence of temperatures can be maintained automatically and easily changed to suit particular batches.

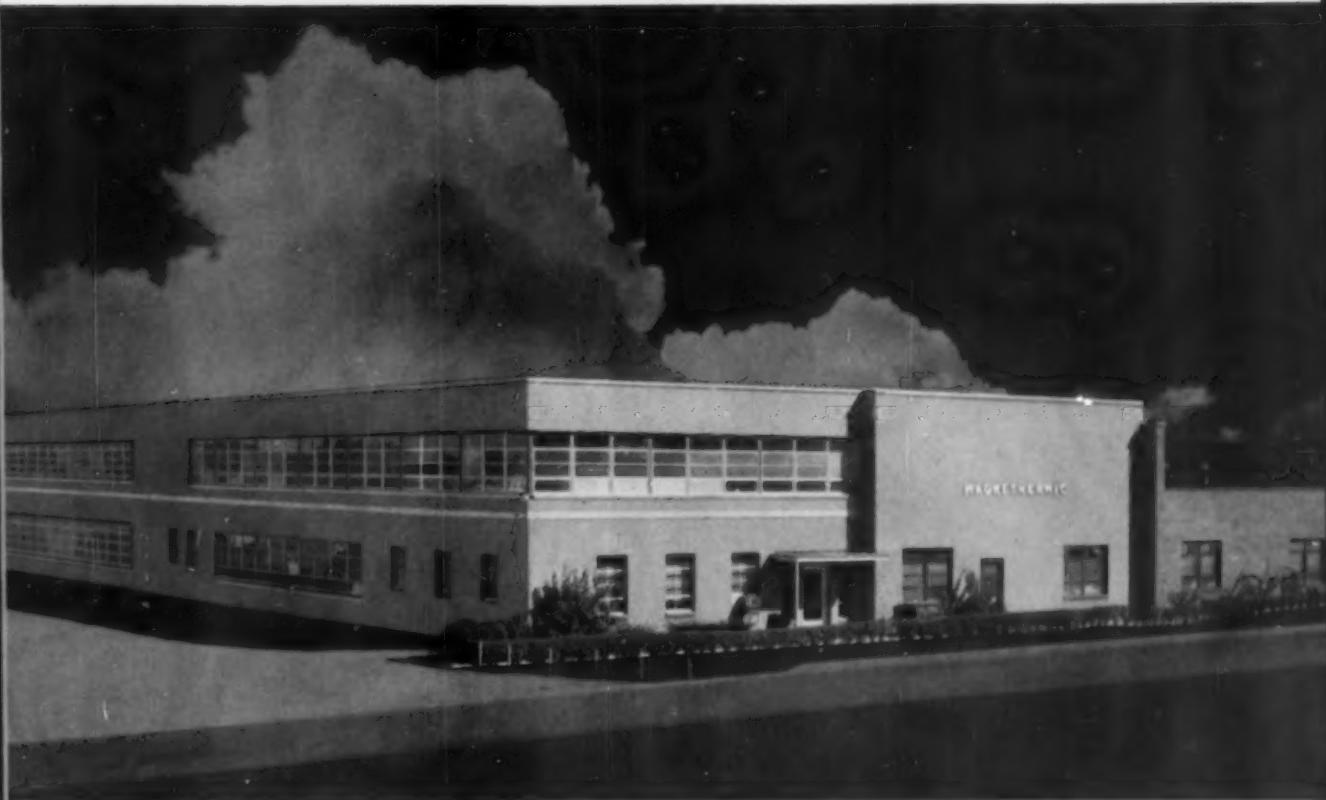


THESE BRISTOL ELECTRONIC AND AIR-OPERATED pyrometers automatically control regenerative soaking pits. Platinum, platinum-rhodium thermocouples at pit covers are sensing elements.

Want to apply these up-to-date control and instrumentation techniques to your industrial heating problem? Bristol engineers will be glad to talk over specific processes, problems, facts and figures with you. Write today to The Bristol Company, 106 Bristol Road, Waterbury, Conn.

BRISTOL POINTS THE WAY IN
HUMAN-ENGINEERED
INSTRUMENTATION
AUTOMATIC CONTROLLING, RECORDING
AND TELEMETRY INSTRUMENTS

INDUCTION HEATING IS OUR ^{ONLY} BUSINESS



**Only one interest here . . . Your Order For
INDUCTION HEATING EQUIPMENT**

Is heating or heat-treating involved in your metal-working process?

If so, let a Magnethermic engineer review your operations and show you what induction heating can do for you.

For example, Magnethermic has designed high frequency equipment for continuous localized heat-treating of electric welded pipe. Another Magnethermic installation pre-heats 32" diameter aluminum ingots, weighing 5,000 pounds, prior to extrusion.

Magnethermic's plant at Youngstown houses diversified facilities and specialized personnel devoting full time to induction heating, Low, Dual and High frequency.

Whether your inquiry concerns heat-treating, hot working or joining, Magnethermic can do the job. For specialized, intelligent attention, place your inquiry with the specialist—Magnethermic.





30 STEAM HAMMERS

can't shake Speedomax® H off control

In the heart of the Chicago steel area, Speedomax H 3-Action P.A.T. recording controllers are helping Standard forgings Corp. turn out quality forgings which range in size from 5 lb. blanks to railroad axles weighing about $\frac{1}{2}$ ton. Subjected to constant and severe vibration from 30 steam hammers and 60 presses for 24 hours a day, 5 days a week, 13 Speedomax H instruments (with five more waiting installation) have been controlling furnace temperatures for over a year with only such routine maintenance as chart changing, etc. And work temperature is held constant within ± 10 F. In both respects, this represents far better performance than the company has experienced before.

In addition to being assured of the correct temperature for each heat, Standard forgings has also

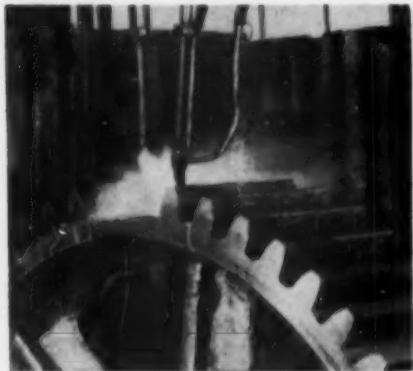
realized the following more tangible benefits since installing Speedomax H: (1) doubled refractory life, (2) reduction in scale with corresponding reduction in bottom cleaning from twice a week to once in two weeks, and (3) fuel savings of 50-75 gallons of oil per shift. Savings realized in increased furnace efficiency alone paid for the instrumentation in a short time.

Perhaps Speedomax H can help solve your temperature problems. For further information, contact your nearest L&N office or write 4927 Stenton Avenue, Philadelphia 44, Pa.

LEEDS
Instruments **NORTHRUP**
Automatic Controls • Furnaces

Flame Hardening

Flame Hardening perfected by LAKESIDE is the process which selectively hardens various components such as gears, cams, rolls, etc. where conventional furnace heat treating methods could not be successful.



Lakeside straightens bar stock

LAKESIDE will heat treat and straighten your bar stock to your specs. LAKESIDE'S facilities can handle round, flat, square and hex bar stock from $\frac{1}{4}$ " to 7" dia. and up to 22' long.



modern scientific

STEEL TREATING

THE *Lakeside way*

Electronic Induction Hardening,
Carbonitriding, Flame Hardening, Heat
Treating, Bar Stock Treating and
Straightening (mill lengths and sizes),
Annealing, Stress Relieving, Normalizing,
Pack, Gas or Liquid Carburizing,
Nitriding, Speed Nitriding, Aerocasing,
Chapmanizing, Cyaniding, Sand Blasting,
Laboratory Physical Testing.

Low carbon steel case hardened through Carbonitriding

LAKESIDE is equipped with the latest automatic facilities to apply precision controlled case hardness to low carbon steel parts. Ask our metallurgist about our carbonitriding service. Investigate, today!



Drawing Furnaces Temper Parts

Pit-type "cyclone" drawing furnaces are generally used for tempering after hardening or heat treating.



Science cuts guesswork in steel treating

Electronic control of temperatures and split-second timing of the treating cycles leave nothing to chance. Materials are processed faster. Production is speeded—quality is improved! Remember—it costs less to deal with specialists!



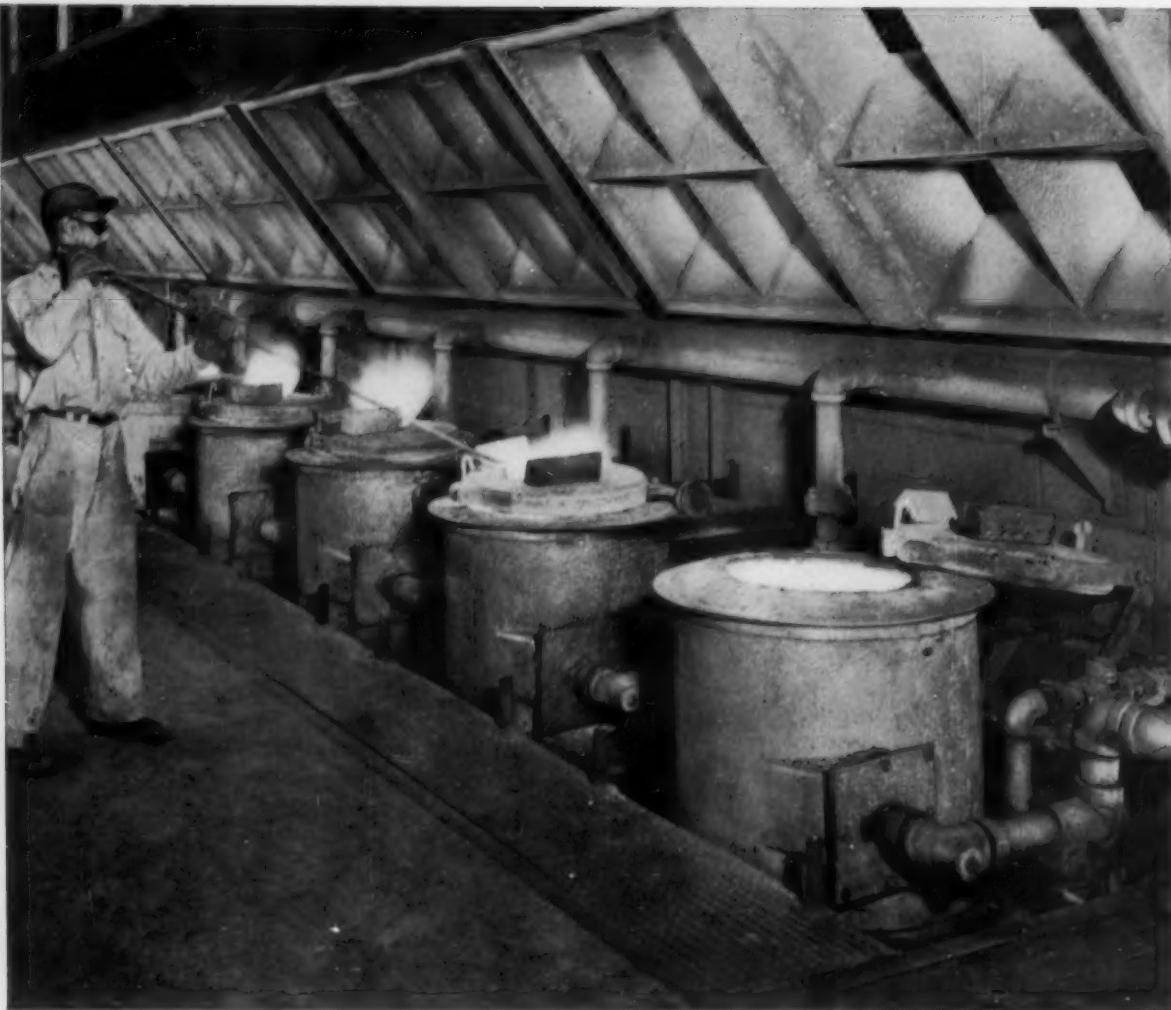
THE

Lakeside Steel Improvement Co.

5418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100



VISIT OUR BOOTH 306 AT THE CONVENTION



**Improved working conditions,
less maintenance,
longer life for crucibles and furnace
linings . . . thanks to GAS**

*Fischer Casting Company, Inc.
Middlesex, New Jersey*

When Fischer Casting Company, Middlesex, New Jersey, moved into their modern new plant, they chose Gas for all their melting facilities.

With Gas operation of all furnaces, closer melting controls are possible. Clean burning Gas, along with modern ventilating equipment, has resulted in better working conditions in melting departments. Furthermore, in the bronze melting department, improvement is shown in the life of furnace refractories and crucibles. Gas also improves the melting operations in the aluminum sand foundry and permanent mold melting

divisions. Three Gas-fired immersion burners heat an 860 gallon quenching tank to 212 degrees F. and one immersion burner maintains this temperature to provide a simple, dependable and accurate method of quenching aluminum castings.

For information on how you can improve your production operations by using Gas, call your Gas Company's industrial specialist. He'll be glad to discuss the economies and outstanding results you get with Gas and modern Gas-fired industrial equipment. *American Gas Association.*

GROWING GROWING GROWING

*The **Kinney**® Vacuum Pump Line continues to grow . . . to meet industry's vacuum needs!!



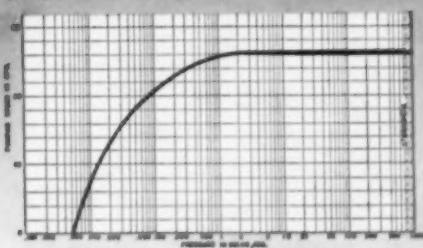
Model KD-30

- ★ Swiftly, accurately, and consistently creates and maintains vacuum desired
- ★ Application versatility
- ★ Thorough dependability
- ★ Low maintenance requirements

MODEL KD-30 SPECIFICATION DATA — Model KD-30

Single Stage-Duplex Design High Vacuum Pump

Ultimate Pressure (McLeod Gauge)	10 Microns	Cooling Shaft Diameter	Air $\frac{5}{16}$ "
Free Air Displacement	30.4 CFM	Inlet Connection	$1\frac{1}{4}$ " screwed
RPM	525	Outlet Connection	$1\frac{1}{4}$ " screwed
Motor H.P.	1 1/2	Net Weight, Complete Unit	370 lbs.
Oil Capacity	2 1/2 qts.		



Our engineers will gladly make recommendations on any of your vacuum equipment requirements. Request complete data today or contact one of our competently staffed district offices . . . in Baltimore, Charleston, W. Va., Char-



Model KMB-230

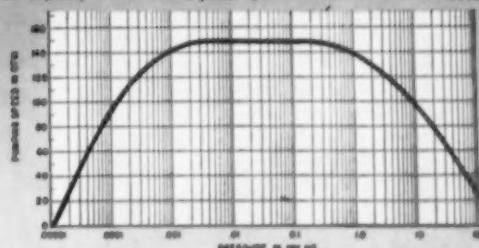
TOP VOLUMETRIC EFFICIENCY!

Though already offering the world's largest line of vacuum pumps, Kinney caters to industrial progress and is constantly developing new pumps to meet the challenge it offers. If your process can be improved by better vacuum equipment, check the design features of these latest additions to the Kinney line . . . and benefit from our wealth of experience in designing and manufacturing quality products.

MODEL KMB-230 SPECIFICATION DATA — Model KMB-230

Two Stage Mechanical Booster Vacuum Pump

Ultimate Pressure (McLeod Gauge)	0.1 Micron	Cooling Shaft Diameter	Water $\frac{5}{16}$ " / $\frac{3}{8}$ "
Free Air Displacement	230 CFM	Inlet Connection	4" flanged
RPM	3600/640	Outlet Connection	$1\frac{1}{4}$ " screwed
Motor H.P.	2 and 1	Net Weight, Complete Unit	1010 lbs.
Oil Capacity	8 pints		



lotte, N. C., Chicago (La Grange), Cleveland, Detroit, Houston, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis . . . or The International Sales Office, 90 West St., New York 6, N. Y.

KINNEY

MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY



3584 WASHINGTON STREET • BOSTON 30 • MASS.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N.Y.

* Please send Catalog No. 425 describing the complete line of Kinney Vacuum Pumps.

* LOOK FOR US IN BOOTH 728 IN THE CLEVELAND PUBLIC AUDITORIUM DURING THE NATIONAL METAL EXPOSITION — OCT. 26TH THRU 31ST.

Name _____

Company _____

Street _____

City _____ State _____

Utica
Metals
Division



UTICA DROP FORCE & TOOL
CORPORATION

UTICA 4, NEW YORK

An Open Letter ON VACUUM MELTING

To the man responsible for product
development and improvement:

The problems of vacuum melting in production quantities have been
solved. There are considerable data available on the properties of
various alloys.

But the work has just begun.

There remain many unexplored promising uses for vacuum melted alloys
-- and these uses must be explored by product manufacturers. To them
we offer our knowledge, our facilities and, within our means,
our purse.

Bring us your problems, your ideas, your questions. If you're looking
to the future you need a supplier who is too.

Sincerely,

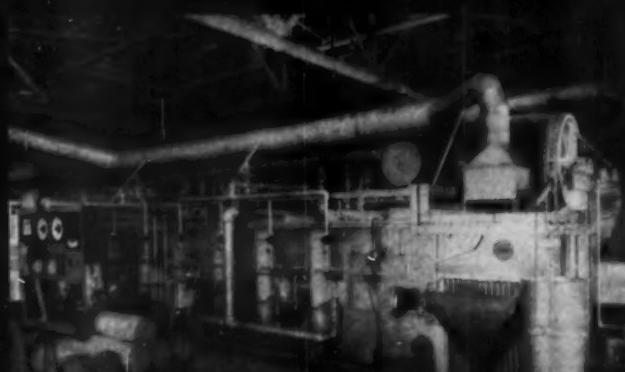
F.N. Darmara
Vice President
Metals Division

P.S. Utica can offer you properties like these through Vacuum Melting:

- High temperature corrosion resistance
- Extreme cleanliness
- Precise chemical control
- Longer stress-rupture life
- Increased tensile strength
- Increased ductility
- Better fatigue resistance
- Greater yield strength
- Greater impact resistance
- Greater creep properties



ECLIPSE BURNERS SPECIFIED ON NEW
ROCKWELL BILLET HEATING FURNACE



Billet Heating
Furnace made by
W. S. Rockwell Co.
Fairfield, Conn.

**for automatically controlled
high production billet heating**

Billet heating furnaces made by W. S. Rockwell Co., Fairfield, Conn., are automatic pushbutton machines every bit as modern as the extrusion presses they feed. The machine shown is installed in a large brass mill and is virtually a mechanical robot which coordinates heating and handling functions to provide automatic control of production rate and quality. Round brass and other copper alloy billets must be heated scale-free. Production rate is based on heating 32 billets 10 in. in diameter by 27 in. long, weighing 630 lb. each, per hour, with 2 hours in the heating chamber.

Precise heating is made possible by use of 20 Eclipse No. 102 ZB Nozzle Mixing Blast Burners. Burners fire over the billets from both sides, using propane, with gas-air mixing at the discharge end of the nozzle. No combustion mixture is carried in the manifolds and back-firing is impossible.

No matter what your combustion problem in industrial furnaces, ovens, or process heating, Eclipse is prepared to solve it, drawing from the most complete selection of combustion equipment available. Send for Bulletin H for further information.

ECLIPSE FUEL ENGINEERING CO., 1127 BUCHANAN ST., ROCKFORD, ILLINOIS
Eclipse Fuel Engineering Co. of Canada, Ltd., 20 Upjohn Road, Don Mills, Ontario

Eclipse

**COMBUSTION
EQUIPMENT**

"Most complete line, anywhere!"

**See you at
the Metal Show!**



We are looking forward to the chance to greet our old friends and meet many new ones at Booth No. 1724 at the Metal Show. Be sure to allow enough time for us to show you our complete burner display, and extensive valve display which includes: spring-loaded automatic temperature control valves; Lock-tite safety shut-off; and solenoid valves. You will also see our adjustable Vari-Set mixers and the exhibit described below.

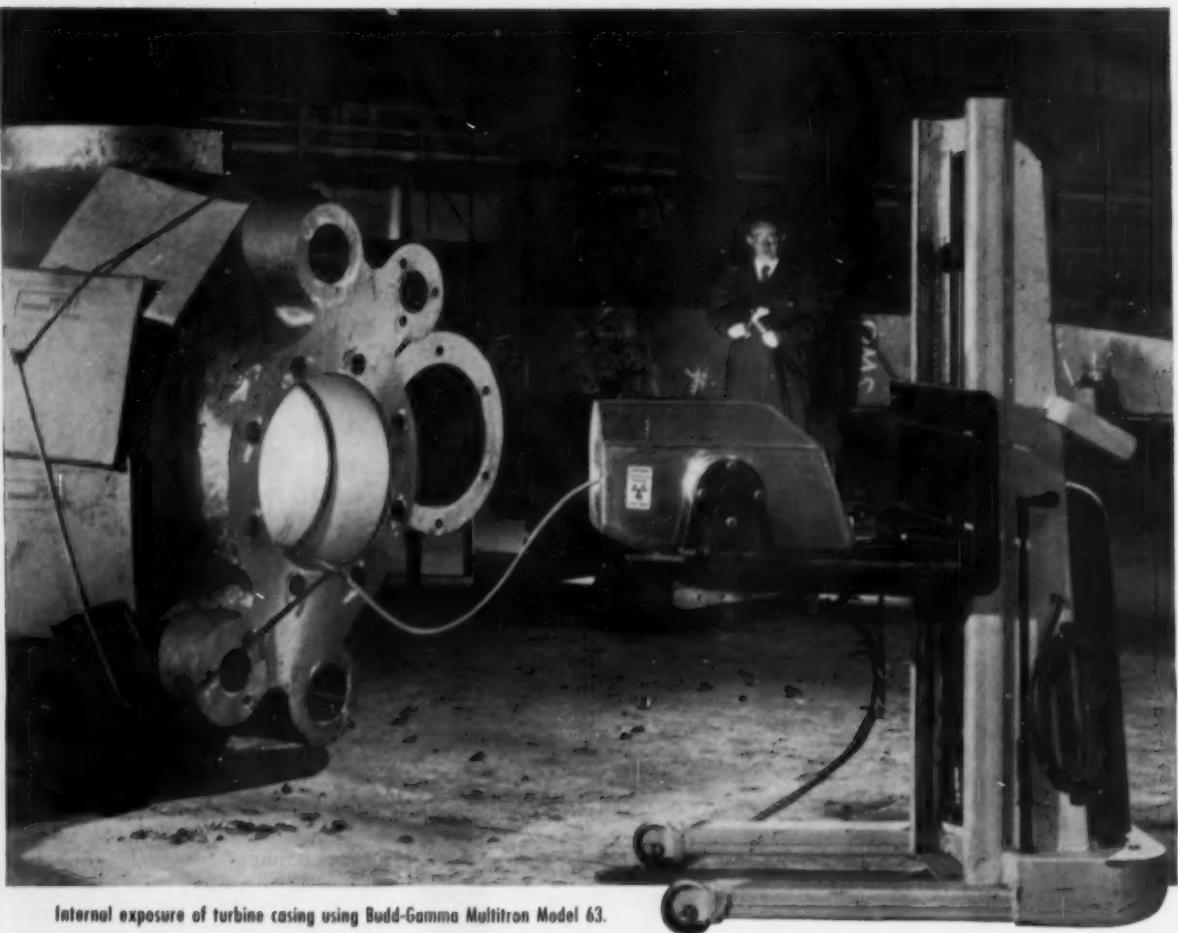
Come to the "Peep-show"

BOOTH 1724



Yes, come to our Peep-show where you can operate our new even-heating Radiant Tube Burners and our new Excess Air Burners which provide oxidizing action in process heating and cooling. Don't miss the chance to see these versatile new burners in operation!

ECLIPSE FUEL ENGINEERING COMPANY



Internal exposure of turbine casing using Budd-Gamma Multitron Model 63.

Budd provides complete Gamma Isotope Radiography Service

The physical and technical resources of The Budd Company are now being directed to the development and manufacture of gamma isotope radiography units.

These units are designed to employ any of the established gamma ray sources, of any required strength, and to provide for panoramic, beam and internal shots.

They are portable and can be operated by one man. They require no attachment to electrical or water lines, consequently they can be

used anywhere. They are fast. Accurate. Economical. Safe.

Budd will train your operating personnel in the use of these devices, and also provides a service for the replacement of gamma sources at scheduled intervals.

For catalogue and complete information, address The Budd Company, Gamma Division, Philadelphia 32.

Budd

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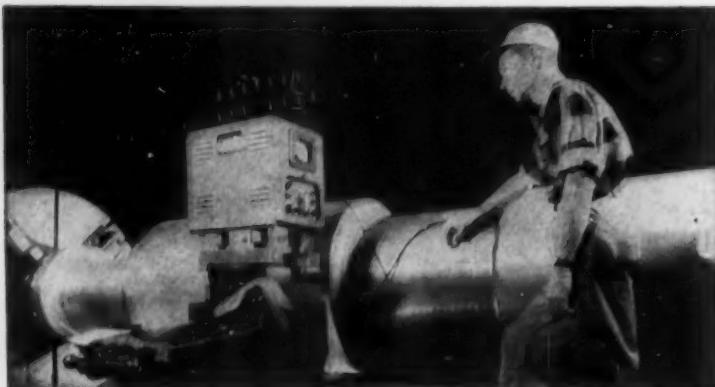
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Sperry

ultrasonic inspection news

HOW ULTRASONIC TESTING HELPS U. S. STEEL PRODUCE FLAWLESS FORGINGS!



This turbine generator shaft—forged and sonic-tested by U. S. Steel—is part of the first nuclear reactor power plant to be built in the United States. The 60,000 kilowatt power plant will go into operation in 1957.

Here, the shaft is being Reflectoscope-tested while it is still in the lathe. The forging will be sonic-tested a minimum of 5 times as it progresses through various stages of manufacturing. At U. S. Steel, turbine and generator rotor forgings are tested at these stages:

1. Preliminary sonic test is run on the rough forgings before machining.
2. Forging is rough-turned to bring it into a "round," then sonic-tested again.
3. After a bore has been drilled through the forging, it gets a complete full-scale sonic inspection.

4. After grain-refining (heat-treatment) another sonic test is made.

5. After finish-machining and stress-relieving, the forging is inspected again as specified by the customer.

All these sonic inspections are usually conducted while the forging is rotating, except for the as-forged test. A carbide tool finish is used to provide a suitable surface for the double-crystal search unit.

This testing for defects before forgings are placed in actual operation enables U. S. Steel to turn out flawless forgings that *exactly* meet ASTM and customer requirements. Reflectoscope inspection saves U. S. Steel man-hours and money...helps assure customer satisfaction! It can do as much for you. Use the handy coupon to ask for full information.



THE SHOW'S ON THE ROAD!

Sperry's new ULTRASONIC CARAVAN is now on a nationwide tour of plants and factories throughout the United States.

The Caravan's compact exhibits will demonstrate every aspect of ultrasonic testing and equipment to management and engineering personnel. You will see all types of Sperry Reflectoscopes, signaling and recording devices—in action...in your own plant...using samples of your own materials or products for testing!

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Sperry Products, Inc.
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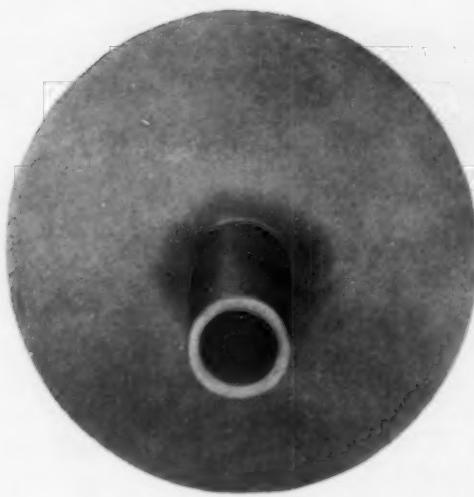
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in any shape or grade . . .

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THIN WALLS — Accurately produced by the Accumet casting process, they are impossible to make in sand or shell mold castings — very difficult to forge.

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CORING — Deep or intricate cores — prohibitively costly to machine — can be economically produced by the Accumet process.

ODD SHAPED PARTS — difficult to chuck and machine, are economical when they're Accumet castings.

Next time your designs call for parts with intricate shapes . . . close tolerances . . . fine finish . . . high quality and uniformity, make them Crucible Accumet castings. They are available in any grade of steel or high alloy your product calls for. Let a Crucible engineer give you all the facts about how Accumet castings can save you time and money. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

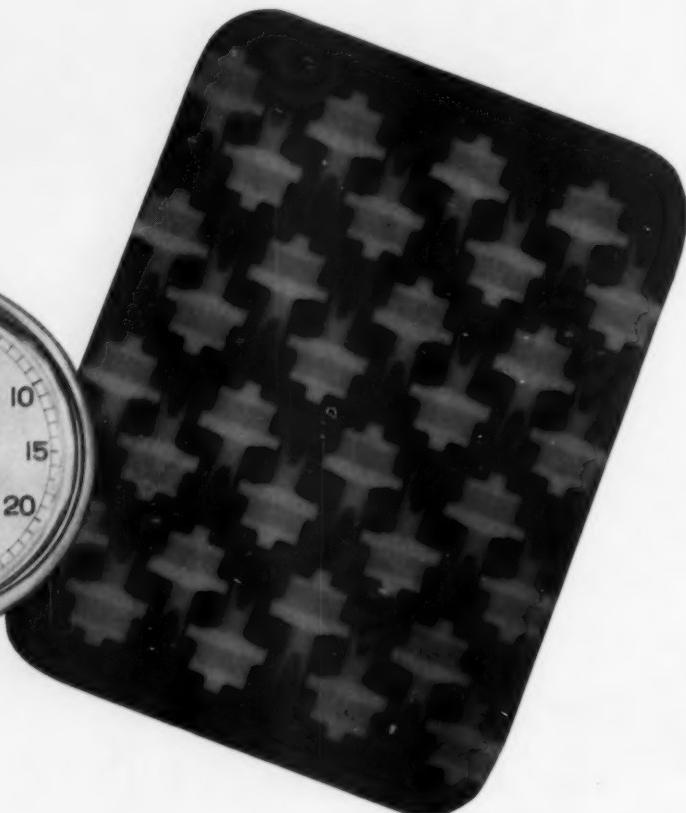
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How can cleaning costs be reduced 33% while cleaning quality is being improved? See pages 7 and 8 in the booklet.

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**Do you need a brass cleaner
that gives better protection
against tarnishing?**

Oakite has a new brass cleaner that provides scientific protection against the oxygen that tarnishes brass and other copper alloys during the application of reverse current.



**"It cut our cleaning rejects
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says a manufacturer who found that Oakite Composition No. 95 gave him:

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**CAN PROTECT HEAT TREATING EQUIPMENT
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The new, ALUMICOAT molten aluminum Process has been perfected to give steels added resistance to corrosion and heat oxidation where continuous high temperatures are a problem.

In the ALUMICOAT Process, heat treating fixtures, trays, etc. are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

The ALUMICOAT Process can give you greater economies through the use of lighter yet more rugged fixtures with a longer life through added resistance to corrosion and heat oxidation!

Send for full details. Your inquiry is invited.

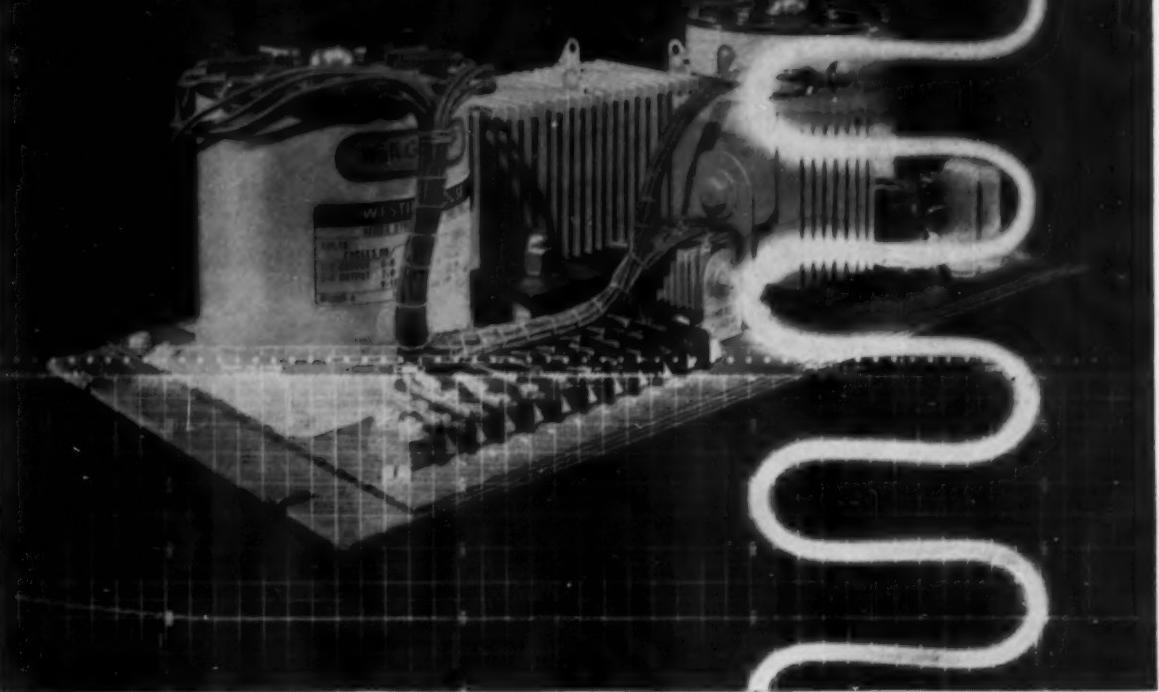
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With Westinghouse Magamp* magnetic amplifiers you can assure extraordinary predictable life for the critical job of amplifying temperature control signals; plus the fact that Magamp controls bring significant dollar savings.

Actually, these link units are rated for at least 20 years of stable, trouble-free service. They are unaffected by heat, dirt or corrosive atmospheres and have no moving parts to stick or jam. In standard panel assemblies, you can apply Magamps for control on industrial furnaces regardless of size.

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Further facts, ratings, and application data for standard Magamp link units are yours in a free Facts Folder. Contact your local Westinghouse sales engineer, or write: Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark
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WHERE BIG THINGS ARE HAPPENING TODAY!



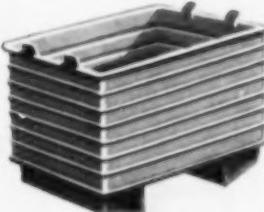
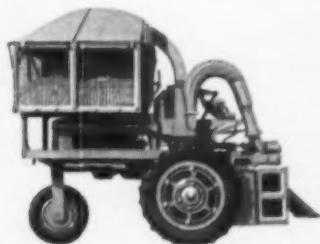
You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

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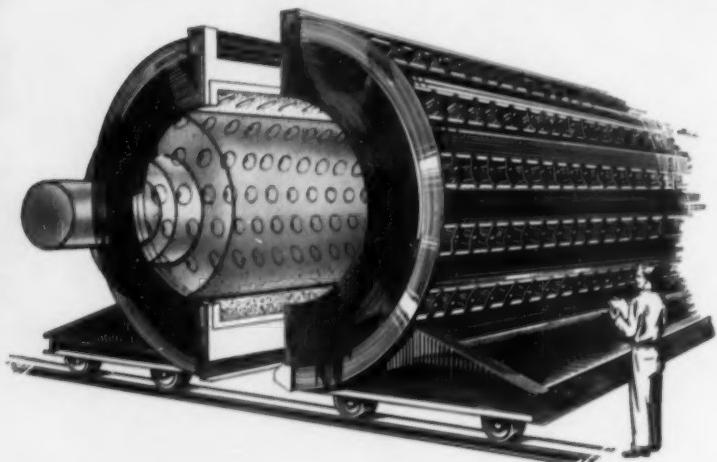
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*Rolls hardened
12 times faster
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Whatever your preference . . . for vertical or horizontal handling of rolls . . . you get the same benefits from Selas Gradiation fast heating:

- Rolls are hardened in only a fraction of the time usually required. In recent production tests, involving 14-inch diameter rolls, heating time was reduced to 95 minutes . . . conventional practice has been 18 hours.
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These two 300 pound TOCCO melting furnaces are powered by a 200 KW, 3000 cycle TOCCO motor generator set.

TOCCO* Induction Melting "Delivers"— In Two Days Instead of Two Months!

Casting backlogs at Commercial Shearing and Stamping Co. in Youngstown, Ohio used to lag from 8 to 10 weeks behind production schedules. By installing four 300 pound TOCCO melting furnaces this firm upped daily melting capacity to 16,000 pounds. Now orders can be shipped in 48 to 72 hours.

In a foundry occupying less than 5000 square feet of space, production of castings jumped between 40% and 50%; tensile strength of alloy castings was boosted from 35,000 to 50,000 p.s.i. Substantial

savings in the cost of castings have resulted. Moreover, with precision casting and molding on a push-button basis, many former drilling and roughing operations were completely eliminated.

Many firms have discovered that TOCCO Induction Melting insures maximum quality control, increased volume and lower operating costs—foundry premiums directly linked to TOCCO's rapid melting, simplicity of operation, low alloy loss, constant burn off and pinpoint quality control.

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CAST BRONZE BEARINGS AND PARTS

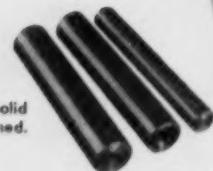
STANDARD STOCK BEARINGS

854 stock sizes Finished Cast Bronze Bearings for oil applications.



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263 stock sizes Tubular and Solid Cast Bronze Bars. Fully machined. 13" long.



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324 stock sizes Finished Cast Bronze Bearings ready for assembly in all popular motors.



SPECIAL BEARINGS

Cast Bronze Bearings and Parts made to customers' blueprints. Send specifications, quantities, material analysis and design to Toledo for prices or recommendations. Engineering services always available.



BABBITT LINED BEARINGS

Cast Bronze with centrifugally cast linings of tin or lead base Babbitt. Send inquiry and specifications to Toledo.



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Cast Bronze Bearings grooved and graphited for special applications.



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553 stock sizes Finished Sintered Bronze Plain Bearings made to ASTM standard sizes, dimensions and tolerances.



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62 stock sizes tubular bars and 22 stock sizes solid bars. 6½" long.



SPECIAL BEARINGS

Sintered Powdered Bronze Bearings made to customers' blueprints. Send specifications, quantities, material analysis and design to Toledo for prices or recommendations. Engineering service always available.



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All stock sizes above listed are available from distributors everywhere in the United States. Catalogs on request. Bunting machine shops in New York City, Chicago, Detroit and Atlanta provide quick service for alterations, grooving and graphiting.

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TOLEDO 1, OHIO • BRANCHES IN PRINCIPAL CITIES

15 times the life in Acid Mixtures

**AND STILL
GOING STRONG**



PROBLEM:

Baskets for submerging alloy steel forgings in hot pickling acids had to be replaced every month because of severe corrosion. The baskets were continually immersed in either 15 per cent hydrochloric acid, aqua regia, 10 per cent nitric and hydrofluoric acids, or 20 per cent nitric acid. All of these acids were at about 140 deg. F.

REMEDY:

The baskets were made of one-inch round bars of HASTELLOY alloy C.

RESULT:

After 15 months' service, three shifts a day, the baskets made of HASTELLOY alloy C are still good.

HASTELLOY alloy C is the most universally corrosion-resistant alloy available today. It has high-strength and is highly resistant to all of the mineral acids. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

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ALLOYS

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uniform HEAT for BIG jobs!



at morgan engineering-alliance, ohio

This 52' x 21 $\frac{1}{4}$ ' x 17 $\frac{1}{2}$ ' high car bottom furnace was designed by Morrison Engineering to stress relieve heavy weldments. The furnace is available for use by other firms on a subcontracting basis. It has the second largest car bed area of any such furnace in the world.

Imagine getting a uniform heat throughout a 250,000 pound load of steel with 3" to 10" thick sections in such a huge furnace! 48 North American No. 223-4 Dual-Fuel Burners do the

trick. These burners, arranged in 4 banks and 3 zones, can burn 250 gallons of oil per hour, releasing 33 million Btu. They maintain a stable fire even when operating with a large amount of excess air to attain good temperature uniformity.

All the air is supplied by a North American Turbo Blower. North American pilots, valves, and Ratiotrols provide a safe, effective control system.

for additional information consult your local n. a. engineer or write for bulletin 223



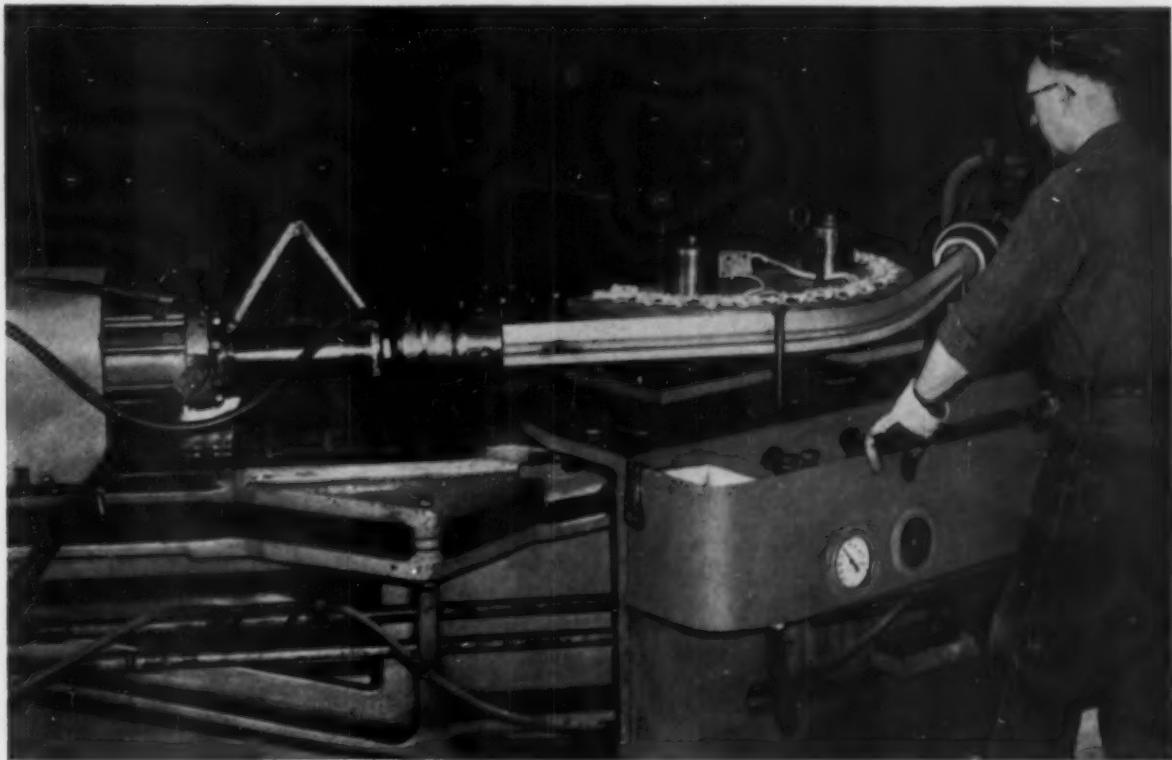
the NORTH AMERICAN mfg co

Combustion Engineers

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MALLORY-SHARON
reports on

TITANIUM



Certified titanium strength helps Bell Aircraft cut fabrication time

• In stretch forming titanium sheet parts, Bell Aircraft found variable springback an annoying problem—requiring expensive hand line-up and re-working. Springback variations of several degrees were encountered with sheets of different strength levels.

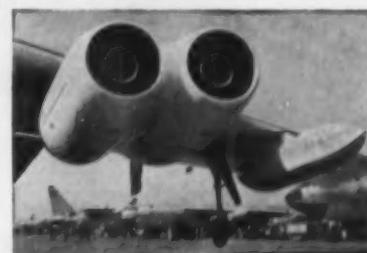
Mallory-Sharon's strength certification has aided Bell's successful effort to reduce time, work and scrap loss in titanium fabrication. Using statistical quality control, we certify the average strength of each tita-

nium heat, and further certify that 97.5% of the heat lies within narrow limits of this value (such as \pm 5000 psi).

This simplifies segregation of incoming material into close strength ranges. Bell color codes and handles each strength level separately. In addition, hot forming techniques have been perfected to reduce variable springback.

Quality certification is another first from Mallory-Sharon contributing to the rapid advance of this new

metal. Call us for your requirements in titanium and titanium alloy mill products, and for technical assistance in application.

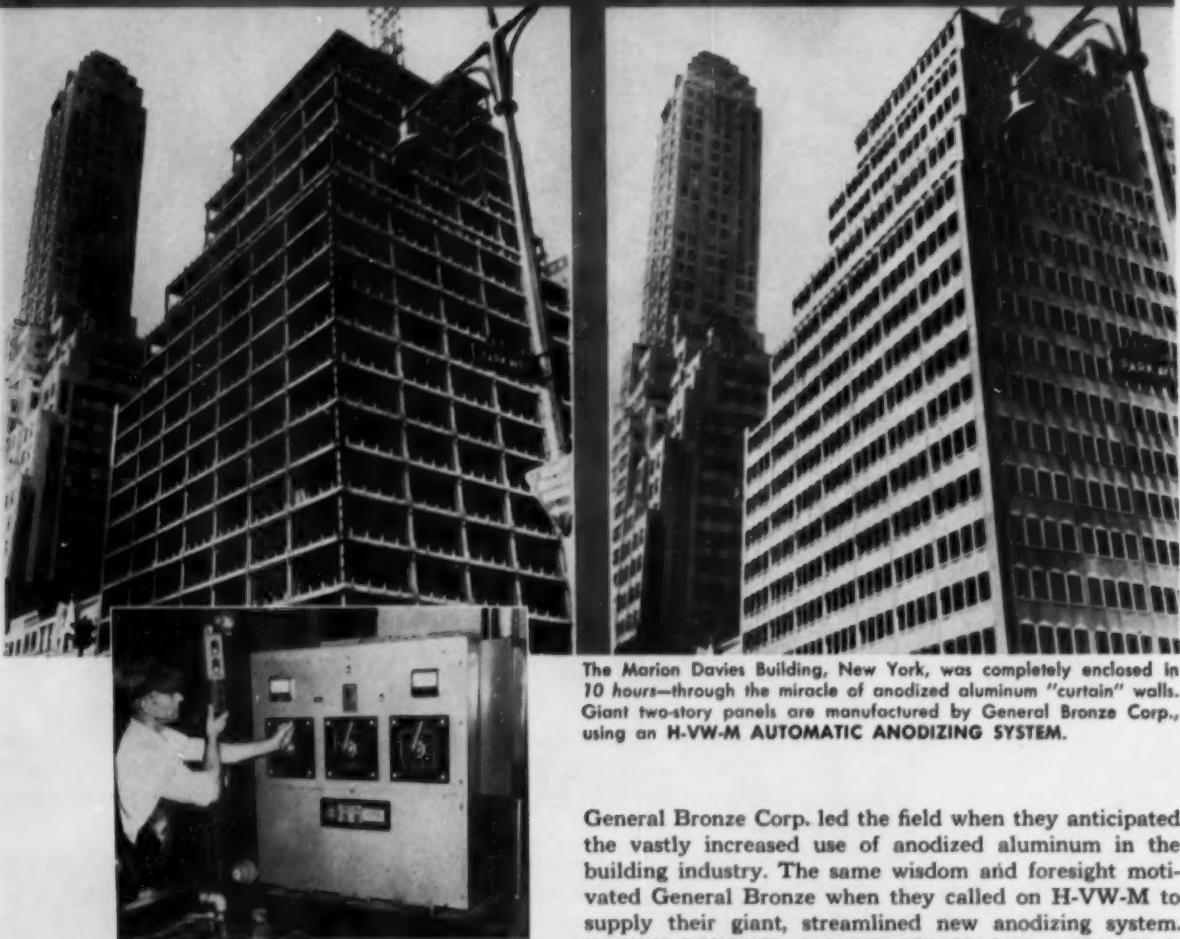


Bell Aircraft produces complete engine pods for the Boeing B-52 jet bomber. Extensive use of titanium in these pods saves approximately 400 pounds gross.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY  **SHARON**

Curtain Going Up!



The Marion Davies Building, New York, was completely enclosed in 10 hours—through the miracle of anodized aluminum "curtain" walls. Giant two-story panels are manufactured by General Bronze Corp., using an H-VW-M AUTOMATIC ANODIZING SYSTEM.

General Bronze Corp. led the field when they anticipated the vastly increased use of anodized aluminum in the building industry. The same wisdom and foresight motivated General Bronze when they called on H-VW-M to supply their giant, streamlined new anodizing system. **H-VW-M DESIGNED, MANUFACTURED AND INSTALLED** it from beginning to end. And the benefits to General Bronze: tripled production . . . improved quality control . . . and the assurance that H-VW-M—the **ONE SOURCE** they chose—assumed **COMPLETE RESPONSIBILITY** for the entire system, from concept to production.

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Your H-VW-M combination—
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—of over 80 years experience
in every phase of plating and
polishing—of a complete
equipment, process and sup-
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Portable Balteau X-ray equipment shown on the job during a typical pipeline inspection. Westinghouse now distributes this versatile line.



Your problem might be solved by fluoroscopic inspection. The exclusive Westinghouse Fluorex Image Amplifier extends the field of internal inspection with fluoroscopy.



Radiographic inspection of large castings is accomplished faster with the stationary 250 KV Constant Potential Unit.

From Pipelines in Texas to Castings in Peoria

Westinghouse Industrial X-ray Equipment
can handle any X-Ray inspection problem

Now — with transportable units, stationary units up to 250 KV capacity, production line units and the versatile fluoroscopic units using image amplification, Westinghouse solves your most difficult internal inspection problems.

If you feel that our staff of Industrial X-Ray Engineers can assist you in any way, please write: Westinghouse Electric Corporation, X-ray Division, 2519 Wilkins Avenue, Baltimore 3, Maryland.

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News about
COATINGS for METALS

Metallic Organic Decorative Protective

New process gives more corrosion-proof chromium plated finish

**Protective coating
60 mils thick or more
with one spraying**

Another improvement in plastisol coatings has again been achieved. Unichrome "Super 5300" Coating delivers the full solids content of vinyl plastisol through a spray gun and builds up a coat 60 mils thick or more in one application. Thinner coatings, too, if desired.



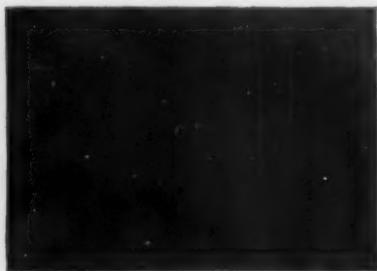
The coating is physically tough and flexible. It doesn't chip or tear. It has the chemical resistance as well as the thickness to withstand acids, alkalies, salt solutions, moisture and other corrosives. It offers better protection for metals with a seamless and pore-free heavy duty coating. Send for Bulletin SP-1.

Unichrome is a trademark of Metal & Thermit Corp.



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CORPORATION**

General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
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In Canada: Metal & Thermit—United Chromium
of Canada, Limited, Toronto 1, Ont.



Top: (Left) After many months outdoors, a .0005" deposit of ordinary chromium, plated directly on steel, was rust-covered; (Right) Crack-Free Chromium, same thickness, was virtually unaffected. Bottom: (Left) Photomicrograph of etched ordinary chromium shows network of microscopic cracks. (Right) Etched Crack-Free Chromium deposit shows no such imperfection.

Experience with a relatively new kind of chromium finish reveals a most important difference in serviceability. This difference is graphically shown above. Uni-chrome Crack-Free Chromium Plating proves definitely, measurably superior to ordinary chromium for certain types of applications . . . notably those where durability and protection are paramount.

REASONS WHY

Crack-Free Chromium is structurally different from ordinary chromium plate. It does not develop the typical network of microscopic cracks — even in thicknesses specified for "hard" chromium plating. Corrosives find no path to the

underlying base metal. Rusting is blocked.

Crack-Free Chromium can be plated directly on steel or zinc base die castings. It does not depend on an undercoat of scarce nickel for long life.

OTHER ADVANTAGES

In other ways, too, the new finish proves superior to ordinary chromium. It resists thermal shock and gives better protection at elevated temperatures. It gives improved non galling, non seizing properties.

Designers who want to give parts solid protection against corrosive conditions will find Crack-Free Chromium well worth evaluation. Send for Bulletin CFC-1.



NEW BOOKLET DESCRIBES LATEST USES FOR STRAITS TIN IN MAJOR INDUSTRIES

Reviews Most Recent Product-Improving, Cost-Reducing Applications. Send for Your Free Copy Now!

This new booklet contains up-to-the-minute information about one of our most useful metals — Straits Tin from Malaya. Booklet explains why tin's properties make it so important to American industry, gives specific examples of new applications solving various manufacturing problems. Sixteen pages, fully illustrated, factual and concise. Write now for your free copy of "STRAITS TIN FROM MALAYA, Its New Importance to American Industry."

The Malayan Tin Bureau
Dept. 25J, 1028 Connecticut Ave.
Washington 6, D.C.

Please send me a free copy of the new booklet, "STRAITS TIN FROM MALAYA, Its New Importance to American Industry."

Name and Position _____

Company _____

Street _____

City _____ Zone _____ State _____



The Malayan Tin Bureau

Dept. 25J, 1028 Connecticut Ave., Washington 6, D.C.

INSULATING FIRE BRICK	Temp. Limit	Density (lb./cu. ft.)	Strength (cold crushing, psi)*	Conductivity (Btu. in. sq. ft. F/lb. at 1000F mean temp.)
JM-3000	3000F*	64	400	3.20
JM-28	2800F*	58	150	2.50
JM-26	2600F*	48	190	2.22
JM-23	2300F*	42	170	1.91
JM-20	2000F*	35	115	1.22
JM-1620	1600F*	29	70	1.02
	12000F**			
Sil-O-Cel® Super	2500F**	40	300	1.95
Sil-O-Cel C-22	2000F**	38	700	1.88
Sil-O-Cel 16L	1600F*	34	350	1.07

*Back-up or exposed

**Back-up only



From Johns-Manville refractory research...

insulating fire brick with balanced properties
for unsurpassed heat-control effectiveness

The nine types of insulating fire brick produced by Johns-Manville offer furnace builders and operators a common advantage—balanced properties!

The Johns-Manville insulating brick formulated for your service gives you the ideal combination of physical and thermal properties without sacrificing one for the other. This means you get unsurpassed heat-control effectiveness... greater economy in furnace design... hours saved

in reaching operating temperatures!

For a good example of the value of balanced properties, take the proved performance of JM-3000 insulating fire brick. Formulated for 3000F temperature service, this insulating fire brick has unusual load bearing strength, high spall resistance, low shrinkage and thermal conductivity proportionate to its density.

Johns-Manville has two strategically located plants for the production

of insulating brick: Lompoc, California and Zelienople, Pennsylvania. Insulating brick are available from the stocks of authorized J-M distributors in key industrial areas.

For complete information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

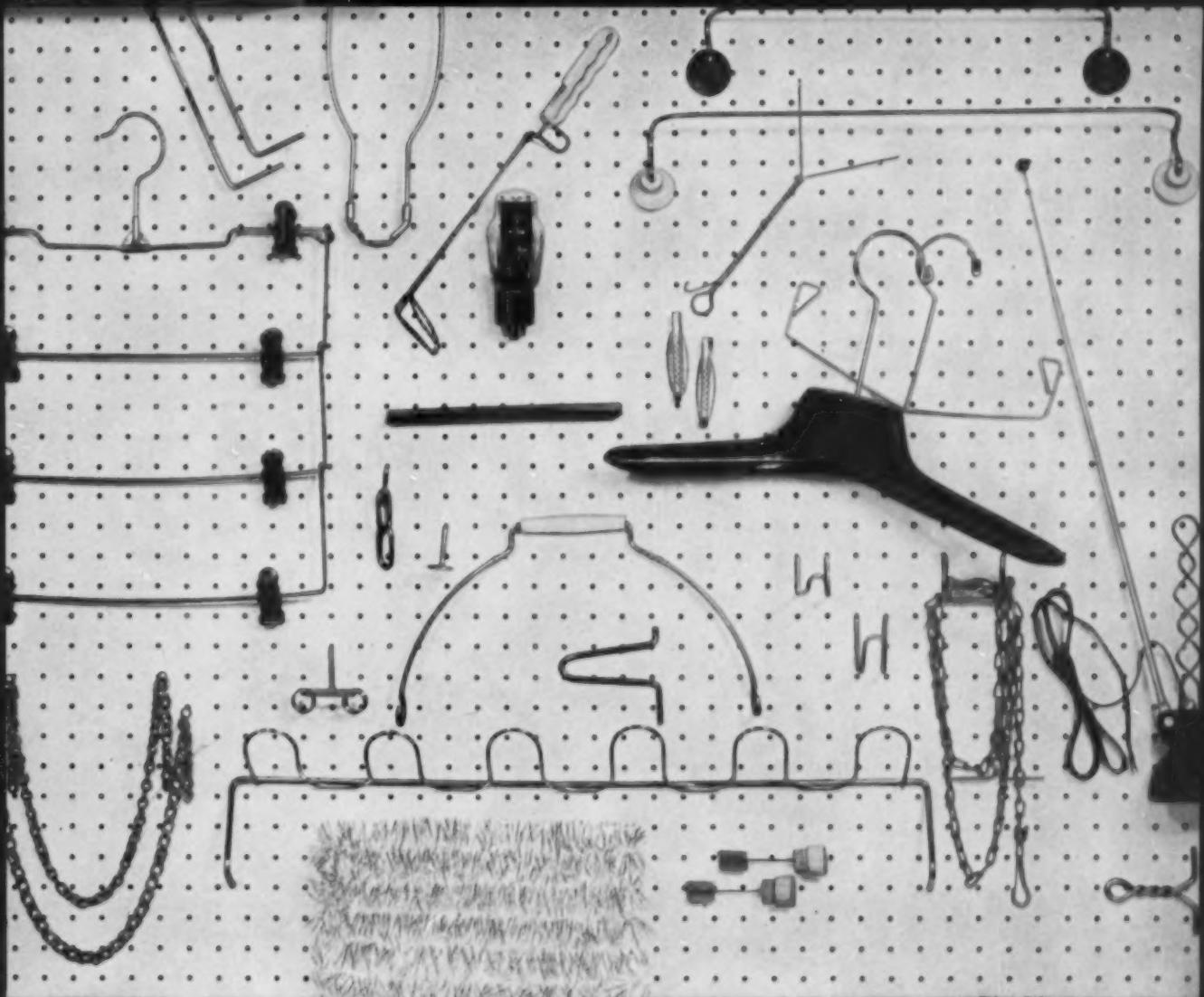


Johns-Manville

REFRACTORY AND
INSULATING REFRactories PRODUCTS

THE INDUSTRY'S MOST COMPLETE LINE OF INSULATING FIRE BRICK





How these products were improved and costs lowered . . .
with **NICKELPLY***, **BRASSPLY*** and **COPPERPLY*** wire!

• National-Standard Nickelply, Brassply and Copperply is electro-jacketed steel wire—a new development offering important advantages to manufacturers and users of wire forms and components. Specifically . . .

The jacket metal, precisely concentric and to the required thickness, is inseparably bonded to the steel wire. The materials can be severely formed, twisted, swaged, welded, roll threaded or redrawn without fracturing the jacket metal or otherwise exposing the base metal. Thus these new materials can often replace solid nickel, brass

or copper wire, or can eliminate the costly post-plating of steel wire forms . . . and with unmatched assurance of coating coverage! Advantages in strength, durability and economy are obvious.

Nickelply, Brassply and Copperply are now available commercially in diameters up to .340". Pertinent data on coating weights, strengths, finishes, base materials, corrosion resistance, etc., are given in Bulletin K-10. Why not send for it now and explore these new possibilities?

*Trade Mark National-Standard Company

NATIONAL-STANDARD COMPANY • HILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth



WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes



**PORTRAIT
OF A MAN
WASTING
MONEY**

ENTHONE
"ENSTRIPS".[®]
can prevent this waste!

"ENSTRIPS" — invented and patented by Enthone,

Incorporated — are chemical products for dissolving one metal from another, quickly . . . economically . . . without attacking the base.

Available for nickel, copper, chromium, zinc, cadmium and silver. For the right stripper for your needs, write to Enthone, outlining your requirements.

Ask for the Enthone "Enstrips" Booklet.

Service Representatives and Stock Points in Principal Cities of U.S.A. and Canada, Brazil, England, France, Sweden, and Germany

ENTHONE
INCORPORATED

442 ELM STREET, NEW HAVEN 11, CONNECTICUT
Metal Finishing Processes • Electroplating Chemicals

This is the seventeenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Uses of Aluminum in Alloy Steels

Aluminum as an element has been known to chemists and metallurgists for many years. It is never found in nature in its metallic state, being derived chiefly from bauxite, an aluminum hydroxide. Bauxite is present in various parts of the world, including several tropical and semi-tropical regions.

When used in the making of alloy steels, aluminum has several important functions. Because of its great affinity for oxygen, it is a reliable deoxidizer. It produces fine austenitic grain size. And when it is present in amounts of approximately 1 pct, it promotes nitriding. The nitriding process could be described as surface- or case-hardening by means of a nitrogenous medium, or by heating in an atmosphere of ammonia gas and dissociated ammonia mixed in proper proportions.

Other effective agents in producing nitrided cases are chromium, vanadium, tungsten, and molybdenum. As a rule, however, the hardest cases are obtained with aluminum-bearing steels, the nitriding grades being a good example. These are usually steels of medium carbon content with additions of chromium, molybdenum, and sometimes nickel.

Generally speaking, the lower the

effective nitriding temperature, the harder the case will be. Aluminum-bearing steels usually show a case-hardness range of 950 to 1150 DPHN (diamond pyramid hardness number). Steels in which no aluminum is present have cases of substantially lower hardness.

If you would care to know more about aluminum as an addition or alloying agent in steels, Bethlehem metallurgists will gladly give you full information. Just write or call us; our technicians are always at your service. They will do everything possible to help make your problems easier. And whenever you need new supplies of alloy steels, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through XVI inclusive, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 16 topics are now available in a convenient 32-page booklet, "Quick Facts About Alloy Steels," and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation



BETHLEHEM STEEL

BOOTH 2661
AT THE SHOW

UNITRON

METALLURGICAL MICROSCOPES

When you visit UNITRON at the Metals Show, you will see for yourself why more and more of our leading industrial firms, universities and research laboratories are turning to UNITRON microscopes. These remarkable instruments have dispelled the myth that unexcelled optical and mechanical performance is inconsistent with low cost.

Even if you are unable to attend the Show, you may have a

FREE 10 DAY TRIAL IN YOUR OWN LABORATORY

by simply requesting the instrument on your company letterhead. There is no cost or obligation and no formal purchase order need be issued. Let the microscope prove its value to you, before you decide to purchase.

UNITRON Metallurgical Microscopes are chosen by such leading firms as . . .

Union Carbide and Carbon
Goodyear Atomic
General Motors
American Smelting and Refining
CBS-Myron
Sperry Products
Raytheon
Arthur D. Little
Corn Products Refining
Sprague Electric
National Bureau of Standards
International Nickel
Firth Sterling
Raybestos-Manhattan
U.S. Dept. of Agriculture
Colorado School of Mines
General Electric
American Brass
Minneapolis-Honeywell Regulator
Procter & Gamble
Glenn L. Martin Co.
E. I. DuPont de Nemours
International Business Machines
National Cash Register Corp.

THIS COMPLETE CATALOG ON UNITRON MICROSCOPES IS YOURS FOR THE ASKING

This colorful, illustrated catalog gives complete specifications on all of the instruments briefly described on this page, as well as others which we know will interest you. Send coupon below for your free copy.

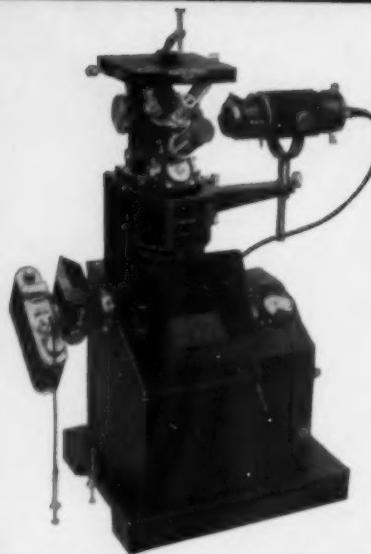


UNITRON

INSTRUMENT DIVISION OF
UNITED SCIENTIFIC COMPANY

Please send us your complete catalog on
UNITRON Microscopes.

Name _____
Title _____
Company _____
Address _____
City _____ State _____

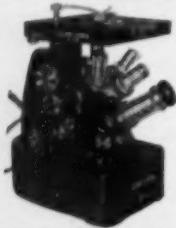


UNITRON METALLOGRAPH and UNIVERSAL CAMERA Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 8 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 25-1800X.
- Compact and sturdy self-contained with built-in 3 1/2" x 4 1/2" camera, high-intensity illuminator, variable transformer.
- The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
- Transmitted light accessories for transparent specimens included.
- Calibrated square mechanical stage with calibrated rotatable stage plate.
- Many other important features and accessories including calibrated polarizing apparatus, filters, micrometer eyepiece, film holders, etc. Cabinet.
- Additional accessories include: Polaroid Land Camera attachment; 35 mm camera attachment; low-power (8-40X) objectives; available at extra cost.

COMPLETE UNIT only \$1145.
fob Boston

BINOCULAR MODEL, BU-11 only \$1319.



UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of opaque specimens. 25-1800X.

- transformer built into microscope base,
- vertical illuminator with iris diaphragm,
- coarse and fine focusing.

- filters: polaroid, frosted, blue, green, yellow.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- coated optics
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: PSX, Micrometer 10X, K10X.

COMPLETE only \$319.
fob Boston

Binocular Model, only \$495.

UNITRON TOOLMAKERS and METALLURGICAL

UNITRON Model TM combines in one stand a toolmakers microscope for precise shop measurements of either opaque or transparent specimens and a metallurgical microscope for the high-power examination of polished metal specimens. Note the many features of this versatile instrument.

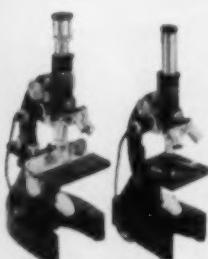
- combination rectangular 1" x 1" ball bearing stage and circular rotary stage
- large micrometer drums read directly to 0.0001"
- dial indicator measures depth, reading to 0.0001"
- substage illuminator for viewing profiles
- surface illuminator
- vertical illuminator for examining grain structure
- transformer built into base
- inclinable tool holder
- coarse and fine focusing
- revolving nosepiece with objectives: 3X, 10X, 40X. Crossline eyepiece, 10X.

Complete only \$1050.



UNITRON MODELS MMU and MMA

These popular laboratory microscopes are ideal for the examination of both metal and transparent specimens under both ordinary and polarized light. In addition to providing vertical incident light, the illuminator may be mounted directly on the stage for oblique lighting and below the stage for transmitted light. The transformer is located conveniently in the microscope base. These models include features found only in instruments selling for over twice our unusually low prices.



MODEL MMU

- coarse and fine focusing
- focusable stage
- calibrated drawtube
- revolving nosepiece—objectives 5X, 10X, 40X, 100X oil
- eyepieces: PSX, P10X, K10X

Complete only \$287.

MODEL MMA

- single focusing control
- revolving nosepiece with objectives 5X, 10X, 40X
- eyepieces: HSX, P10X, K10X

Complete only \$149.

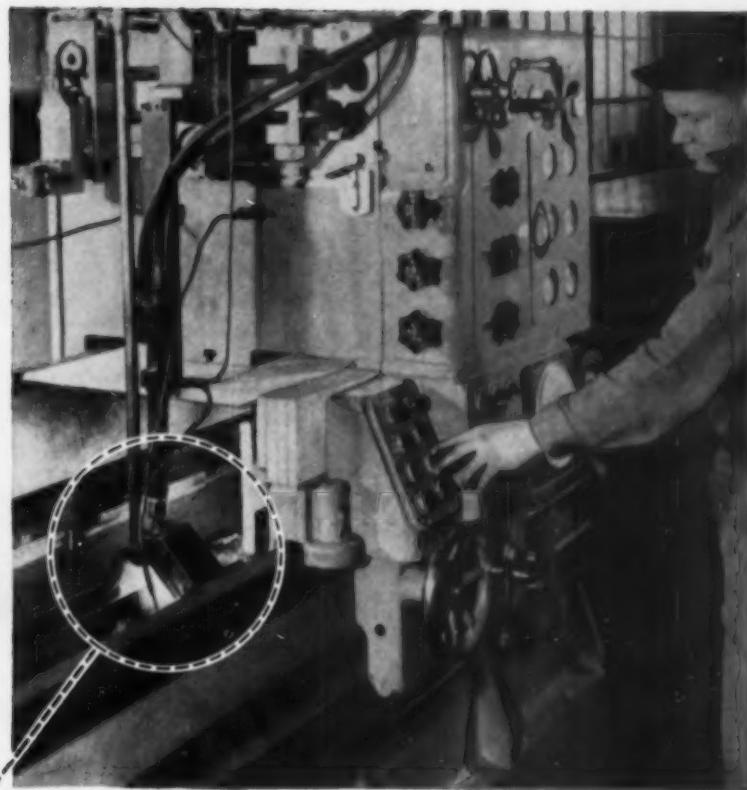
All microscope prices are subject to change without notice.

UNITRON

INSTRUMENT DIVISION OF
UNITED SCIENTIFIC COMPANY

204-206 MILK STREET - BOSTON 9, MASSACHUSETTS

HIGH SPEED FLAME- HARDENING



Cross-section view shows uniform depth of hardened surface.

SPECIAL MACHINE UPS LIFE OF GRAPHITIC STEEL PARTS

LINDE engineers have assisted Cincinnati Steel Treating Company in developing a flame hardening machine which increases service life of 16 ft. long, graphitic carbon steel lathe ways . . . Development of this automatic, high speed machine is another example of how LINDE Service Engineers are helping LINDE's customers up production speed and unit quality through co-operative research engineering.

With this new machine, a lathe way to be treated is placed on a magnetic chuck in a water filled channel. Flame-hardening heads and control mechanism move at predetermined speeds along the part. After it cools, the lathe way is placed in a refrigerator for 24 hours which stabilizes the steel, and brings its case hardness to a minimum of 60 Rockwell "C" scale.

The benefits of LINDE's research, engineering, and over 40 years of accumulated know-how stand behind each of its customers to help them solve production problems. Get these "plus-values" which LINDE offers—it pays you to do business with LINDE.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N.Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

SEPTEMBER 1958

Linde
Trade-Mark

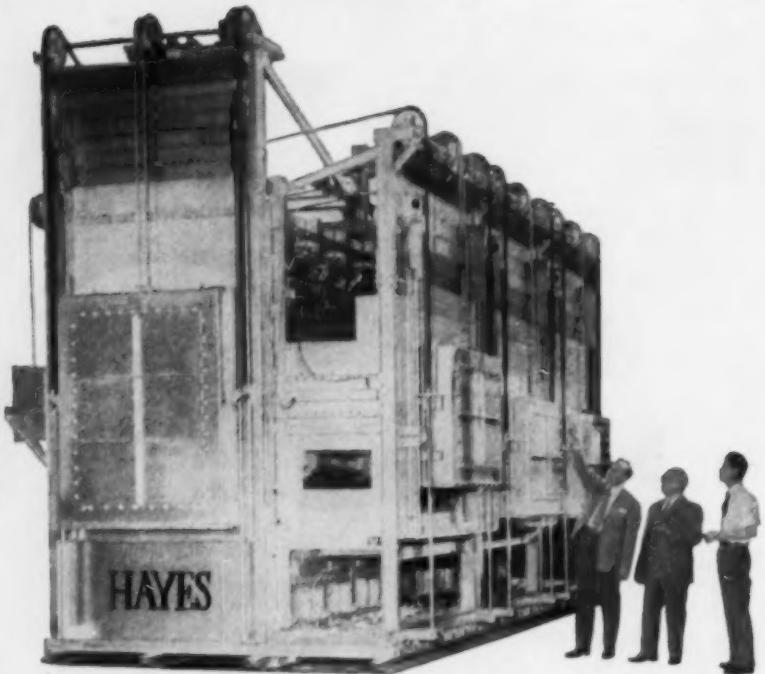


from

small
"package"
units

to

large
forging
furnaces



Hayes "Certain Curtain" spans the field of
**CONTROLLED-ATMOSPHERE
ELECTRIC FURNACES**

. . . and offers the famous "Pre-insured" Purchase

Over fifty years experience in old and new fields of heat treatment gives Hayes the know-how to help solve your heat treat furnace requirements. Our laboratory and technicians assist in developing the correct heat treatment for your samples. This "pre-insures" your purchase: proves BEFORE you buy, exactly what results your heat treat department will get from your investment in Hayes equipment.



IN THE HAYES LABORATORY
YOUR RESULTS ARE "PRE-INSURED"



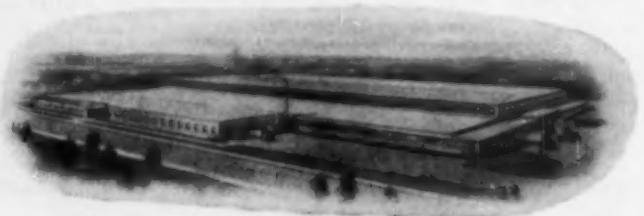
Only Hayes Humpback has
"ABD" High-production Feature

Our famous "Humpback" Furnace is widely imitated . . . but no other offers our patented AUXILIARY Belt Drive, which is absolutely necessary to *High Production*; enabling the furnace to turn out several times more work than with ordinary belt drives.

Consult your local Hayes representative. Request new 1956 Catalog.

C.I.HAYES, Inc.

ELECTRIC CERTAIN CURTAIN FURNACES



887 Wellington Avenue, Cranston 10, R. I.

Electric Heating Equipment Since 1905



Designing parts from *Carpenter* Stainless No. 20 helps tame corrosive rocket fuels

Internal parts of "flow sensing" units which control the flow of fuel to rocket engines, must combine super corrosion resistance and mechanical durability. They meter liquid oxygen at -297°F and a 90-98% concentration of red fuming nitric acid. That's why these critical parts were designed with the super corrosion resistance of Carpenter Stainless No. 20, and machined from No. 20 bar stock.

The units measure fuel flow accurately to within $\frac{1}{10}$ of 1%. Yet they are so durable that when rocket experts dig wrecked missiles out of desert sands they recover the units for re-use.

When you design parts, components or complete pieces of equipment for handling sulphuric acid or other strong corrodents, consider the economy of designing with this super corrosion-resisting stainless.

Call your nearest Carpenter Mill-Branch Warehouse, Office or Distributor . . . or write direct for full information on the cost-saving advantages of Carpenter Stainless No. 20.

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

Carpenter STEEL

Super Corrosion-Resistant Stainless

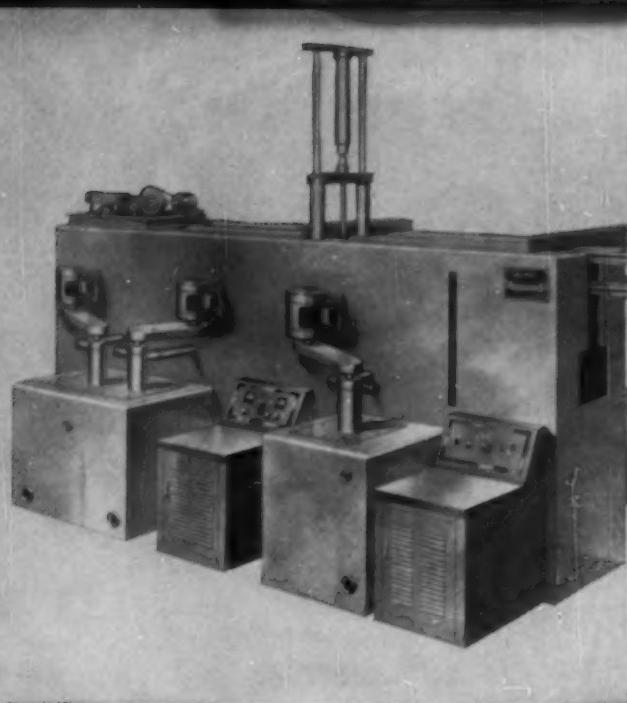
Pioneering in Improved Tool, Alloy and Stainless Steels through Continuing Research

The Carpenter Steel Company, 133 W. Bern St., Reading, Pa.

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"



The new Bendix Unitized Ultrasonic Cleaner



The new Ransohoff Conveyorized Cleaning System

NOTHING CLEANS SO CLEAN AS THE BENDIX ULTRASONIC CLEANER—SELECTED BY RANSOHOFF FOR USE IN ITS NEW CONVEYORIZED CLEANING SYSTEM

The experience of several hundred users has demonstrated conclusively that Bendix Ultrasonic cleaning is far faster, far cheaper, and three to seven times more effective than any other method of cleaning parts and assemblies.

Grease, lapping compounds, cutting oils, abrasives, and other contaminants that can be troublesome to parts and assembly performance are removed 99.5% to 100%... in seconds.

Of prime interest today, users' reports show that Bendix Ultrasonics reduces cleaning costs drastically. Direct labor savings amount to as much as 75%. Rejects, due to the presence of contamination, become practically non-existent. Savings from using water-detergent solutions, instead of expensive solvents, frequently run 90%... and more.

How are all these benefits possible?

Because for the first time a revolutionary... and better... cleaning principle has been successfully applied to today's volume cleaning jobs. Bendix high-frequency sound waves "break loose" contamination from metal parts and assemblies as no other method can. These Bendix "scrubbing fingers" easily reach into tiny crevices, blind holes and other areas too complicated for other cleaning methods to touch.

And now Ransohoff, Inc., a foremost builder of cleaning machinery, offers industry a fully-automated ultrasonic cleaning system that applies the Bendix Ultrasonic Cleaner in a five-stage Ransohoff production line conveyor.

See both new units for the first time at the Metals Show!

Don't miss the system in action at the Ransohoff booth. Visit the

Bendix booth for a complete picture of the many different ways that ultrasonic cleaning is helping industry today. PIONEER-CENTRAL DIVISION, BENDIX AVIATION CORPORATION, DAVENPORT, IOWA.

West Coast Office: 117 E. Providencia, Burbank, Calif.
Southwest Distributor: Southwestern Eng. & Equip. Co., 3906 Lemmon Avenue, Dallas, Texas. Export Sales and Service: Bendix International Division, 205 E. 42nd Street, New York 17, New York. Canadian Distributor: William Wilson, Ltd., 11 Front Street, East, Toronto, Canada.

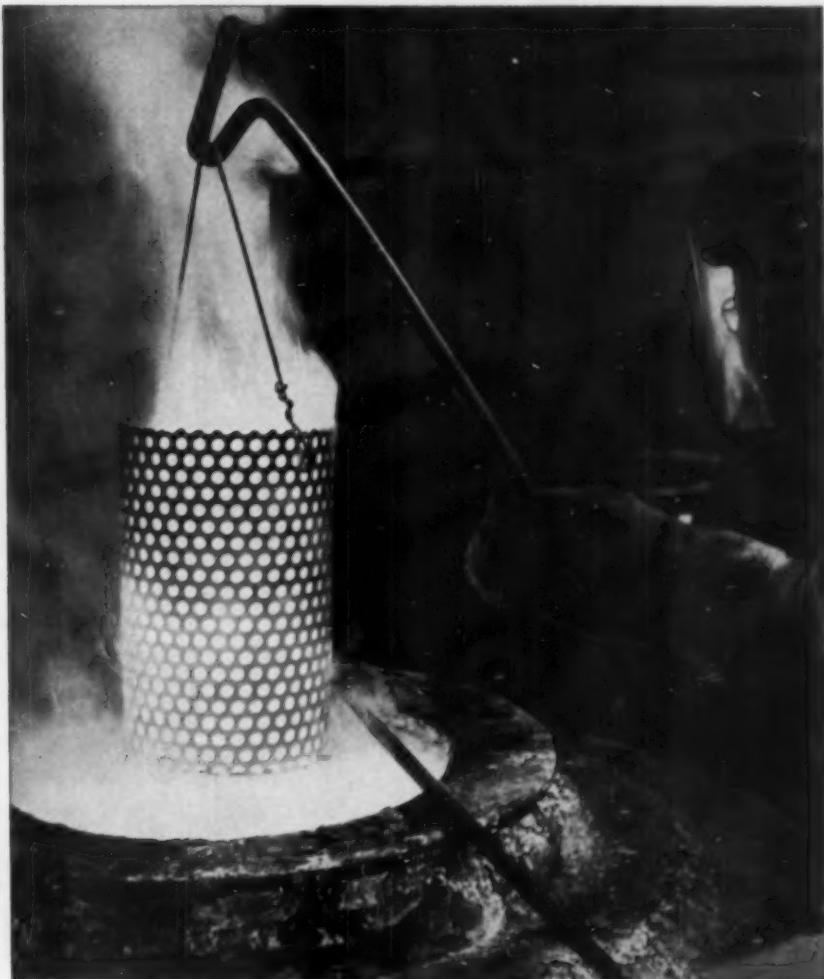
See CONVEYORIZED
ULTRASONICS IN ACTION
at the
**NATIONAL
METAL EXPOSITION**

CLEVELAND, OCT. 8-12

Ransohoff: Booth 2734 Bendix: Booth 2123

Pioneer-Central Division





Every pound costs less to process in long-lasting Inconel alloy neutral salt pots properly fabricated and inspected.

INCO NICKEL ALLOYS
ESCO MARS

This wrought Inconel pot stayed hot eleven months, without failure

Think how this cuts salts bath operating costs

Neutral salt pots aren't usually expected to last 8000 hours. But carefully fabricated wrought Inconel* nickel-chromium alloy pots have.

Take *this* one. When the above photograph was taken it had been going for eleven months without shut-down. During this period it was operated at the customary 1500-1600°F, idled at about 1350°F.

The users, A. F. Holden Co., (Detroit Plant) had never previously used a wrought Inconel Alloy pot. So they're pretty enthusiastic about this one. It's

brought their pot costs way down. And it's been a relief and a saving not to tear down the installation for frequent pot replacement.

Fabricated by Misco

Salt pots owe as much of their success to good fabrication as to the properties of the alloy used.

Recognizing this, the Holden Co. ordered this pot and, later, a stand-by

successor from Misco Fabricators.

Misco skillfully formed and welded both under proper conditions . . . then X-ray inspected them.

You can ask a good deal of wrought Inconel alloy that has been properly fabricated. Not only for neutral salt pots but for most equipment subject to severe corrosive attack and prolonged high temperatures.

*Registered Trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Inconel ...for long life at high temperatures

Yours FREE!

TECHNICAL LITERATURE

1. VALVE TECHNICAL DATA . . .

Twelve page technical manual giving design, selection, maintenance and repair data for stainless steel valves.

2. GETTING THE MOST OUT OF YOUR VALVES . . .

Four page technical discussion explaining selection, installation, inspection and maintenance of stainless steel valves.

3. CATALOG 55D (VALVES) . . .

Sixty-eight page simplified stainless steel valve catalog includes engineering drawings, weights, size ranges, dimensions and basic material data.

4. CATALOG 55F (FITTINGS) . . .

Complete stainless steel fitting catalog giving engineering drawings, dimensions and basic material data.

5. VALVES TO COMBAT CORROSION . . .

75 questions and answers selected from Cooper Alloy valve clinics covering materials, operations, service problems, installation and repair.

6. STAINLESS STEEL VALVES AND FITTINGS IN THE PAPER INDUSTRY . . .

Eight page technical article covering alloys, valve selection, design factors, installation, maintenance, operation and inspection of stainless steel valves and fittings used by the paper industry.

7. PLASTIC PUMPS . . .

Four page folder describing the Vanton "Flexi-Liner" pump. Full and cut-a-way views, plus performance charts and material selection hints are included.

8. PLASTIC PIPE AND FITTINGS . . .

8 page catalog on Vanton P-Line (PVC), N-Line (Buna N) and S-Line (Styrene) pipe, valves and fittings.

9. PUMPING CORROSIVES . . .

Four page article describing the transfer of hydrochloric, formic, lactic acid and salt solutions at Litho Chemical.

10. ADVANCED KNOW-HOW . . .

Series of case studies showing how advanced know-how made possible the economical production of high alloy products considered difficult or impossible to cast.

11. MATERIALS SELECTION CHART . . .

Four page chart designed to assist in the selection of the most economical alloy for a given corrosive problem. More than 350 specific corrosives are included.

12. DESIGN CONFERENCE . . .

Special edition of Newcast containing the technical papers presented at the Cooper Alloy Design Conferences. Subjects include Casting Design, Shell Molding, Cast Weld and New Materials.

13. ALLOY REFERENCE CHART . . .

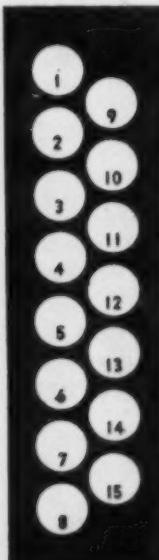
Revised four page pamphlet listing alloy designations, applications, properties and analysis of corrosion and heat resisting alloys.

14. STAINLESS STEEL CASTINGS ON PARADE . . .

Four page folder presenting a variety of cast parts with information as to alloy, weight, application. Complete data chart listing twenty-eight alloys with recommendations for their use is included.

15. NEWSCAST . . .

An eight page bi-monthly publication devoted to reporting technical material of value to those interested in corrosion resistant castings, fittings, valves and pumps.



COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

• FOUNDRY PRODUCTS DIVISION • VALVE & FITTING DIVISION • VANTON PUMP & EQUIPMENT CORP.
• STAINLESS ENGINEERING AND MACHINE WORKS DIVISION • AIRCRAFT PRODUCTS DIVISION

check here for FREE literature

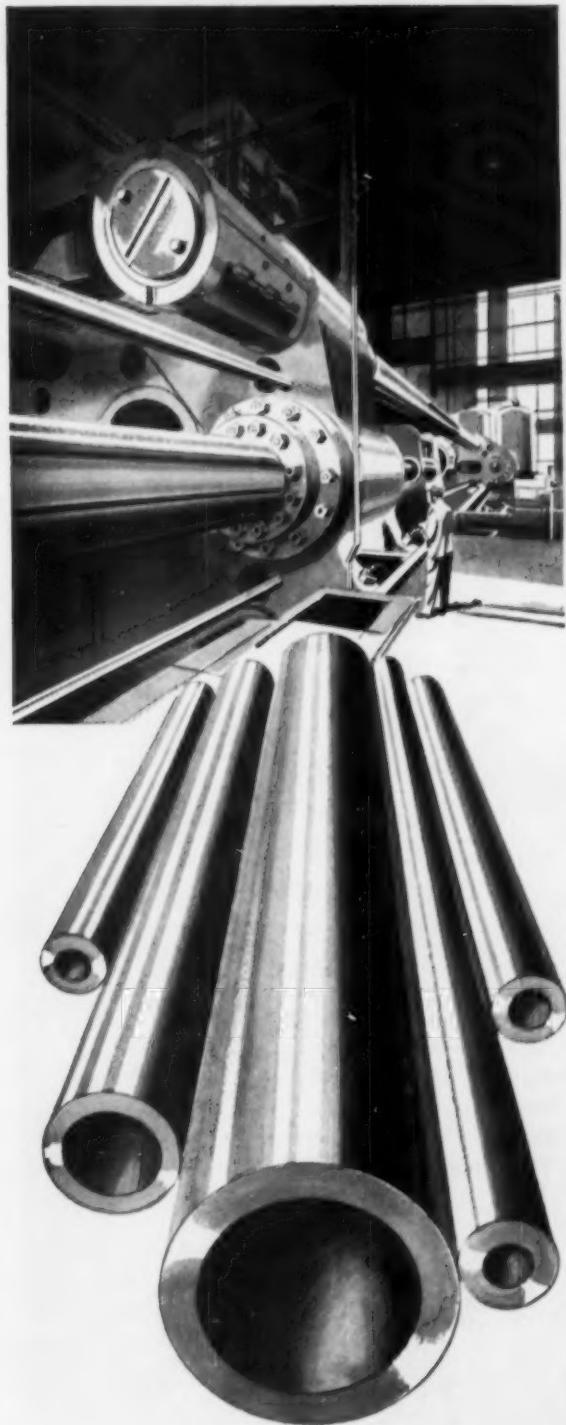
Name _____ Position _____

Company _____

Address _____

City _____ Zone _____ State _____

NOW! from the world's largest
horizontal steel extrusion press . . .



**SEAMLESS
HEAVY
WALL
PIPE**

from any ferrous alloy

Now heavy wall pipe can be extruded from any ferrous alloy — in lengths up to 50 feet or more, with O.D.'s from 4" to 22", and with virtually no restriction on wall thickness.

The giant Curtiss-Wright horizontal extrusion press, now operating at the Metals Processing Division, moves the metal instead of removing it, for pipe of maximum length — and strength.

If your application calls for higher heat, corrosion and/or abrasion resistance — in pipe of highest tensile and yield strengths — Metals Processing Division is geared to fill the requirement. Complete facilities for handling any ferrous alloy, including the stainless series, as well as titanium and other reactive metals, are available to the chemical, petroleum, power and other key industries.

Take advantage of this new, aggressive facility for your pipe requirements. Write, wire or telephone for detailed information or engineering consultation today. Our field engineers are at your service.

METALS PROCESSING DIVISION
CURTISS-WRIGHT 
CORPORATION • BUFFALO, NEW YORK

QUALITY and DEPENDABILITY Right Down The Line . . .



. . . Because **WELDCO** Pipe and Tubing Are Made
With The Exclusive Double-Fusion Welding Process

You get quality, uniformity, dependability in every length of WELDCO Tubing, because WELDCO is produced by specialists . . . men who have the experience, equipment, and facilities to make Pipe and Tubing to your exact specifications.

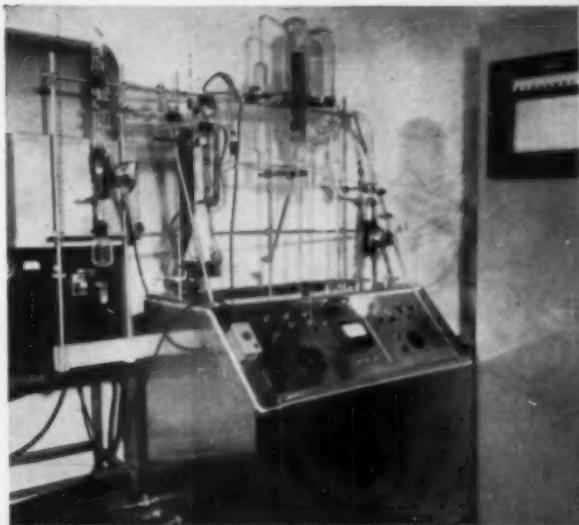
WELDCO is available in Stainless Steel, Monel, Inconel, Nickel, Cupro-Nickel, and Hastelloy, in Tube and Pipe sizes from 3" to 30", Schedules 5, 10, and 40. For special problems, or regular applications, always specify WELDCO and be sure of getting top-quality, dependable products!

*Whatever Your Needs In Tubing . . .
You're 'Way Ahead With WELDCO*

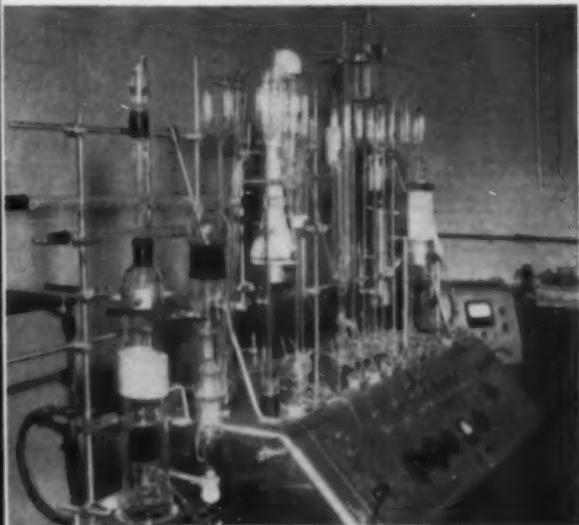
THE YOUNGSTOWN WELDING & ENGINEERING CO., 3718 Oakwood Ave., Youngstown 9, O.

WELDCO

New Developments for Analyzing Gases in Metals



NRC MODEL 917 Hydrogen Analyzer, new quality control and research tool.



NRC MODEL 912B Vacuum Fusion Gas Analyzer, the accepted standard for determining gas content of metals.

New Vacuum Analyzer for Determining

HYDROGEN in TITANIUM

Here is a fast, accurate, low-cost method for determining directly the hydrogen content of titanium. This new Model 917 Hydrogen Analyzer can also be used with zirconium and similar metals. It has a range of 5 to 700 ppm with a precision better than plus or minus 5 per cent. An analysis can be completed in 5 to 10 minutes. It is simple to operate and maintain and can be run by any competent laboratory technician. Data are automatically recorded. NRC analysts install and calibrate equipment and instruct operator.

ANALYTICAL SERVICE. If your requirements do not justify purchase of an instrument, use the services of the NRC Analytical Department. Write for details and NEW low prices.

See us in
Booth 2108
METAL SHOW
Cleveland
October 8-12



Improved Standard Vacuum Fusion Gas Analyzer can

DOUBLE No. of ANALYSES per week

This apparatus is the accepted standard for accurately determining the amount of oxygen, nitrogen and hydrogen in the range of 1 to 10,000 ppm by weight in a wide variety of metals and alloys. Model 912B now has two removable furnace assemblies. By cleaning one while the other is outgassing, down-time is reduced. Improved halogenated graphite cuts outgassing time. The resulting reduction in make-ready time can double productivity for some metals such as titanium. NRC analysts install and calibrate equipment and instruct operator.

NRC EQUIPMENT CORPORATION

A Subsidiary of

NATIONAL RESEARCH CORPORATION

Dept. 19, Charlemont Street, Newton Highlands 61, Massachusetts

Send more facts on Model 917 Model 912 Gas Analysis Service

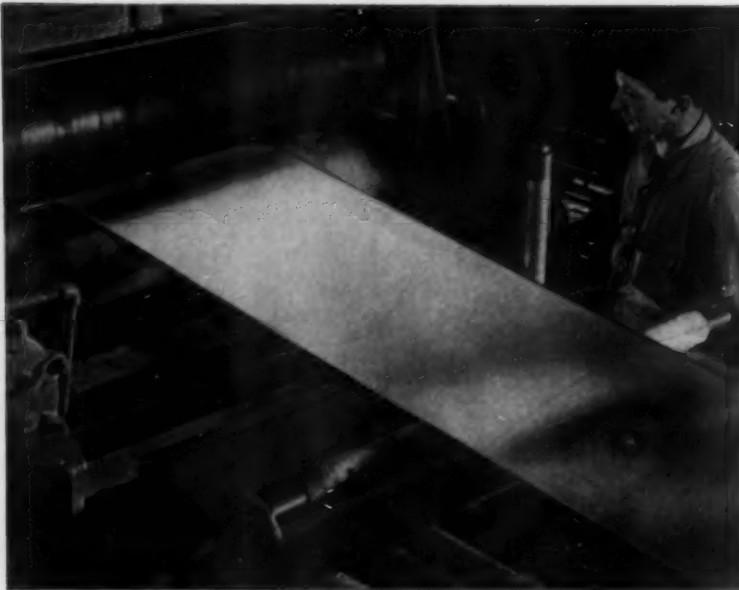
Have your representative call

Name..... Title.....

Company..... 1.....

Address.....

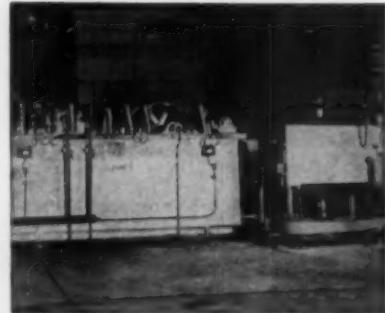
City..... Zone..... State.....



TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.



10-MINUTE IMMERSION loosens scale on 5 tons of stainless wire. A water quench, 3-minute acid dip, and final water rinse produce a clean, bright surface with no pitting or etching.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.



Send for these bulletins—Get the whole story on Virgo Descaling Salt for alloy steels and titanium . . . how the Hooker Process works, its advantages, how to set up a Virgo descaling line, and the services you enjoy as a user. No obligation. Write us today.

From the Salt of the Earth

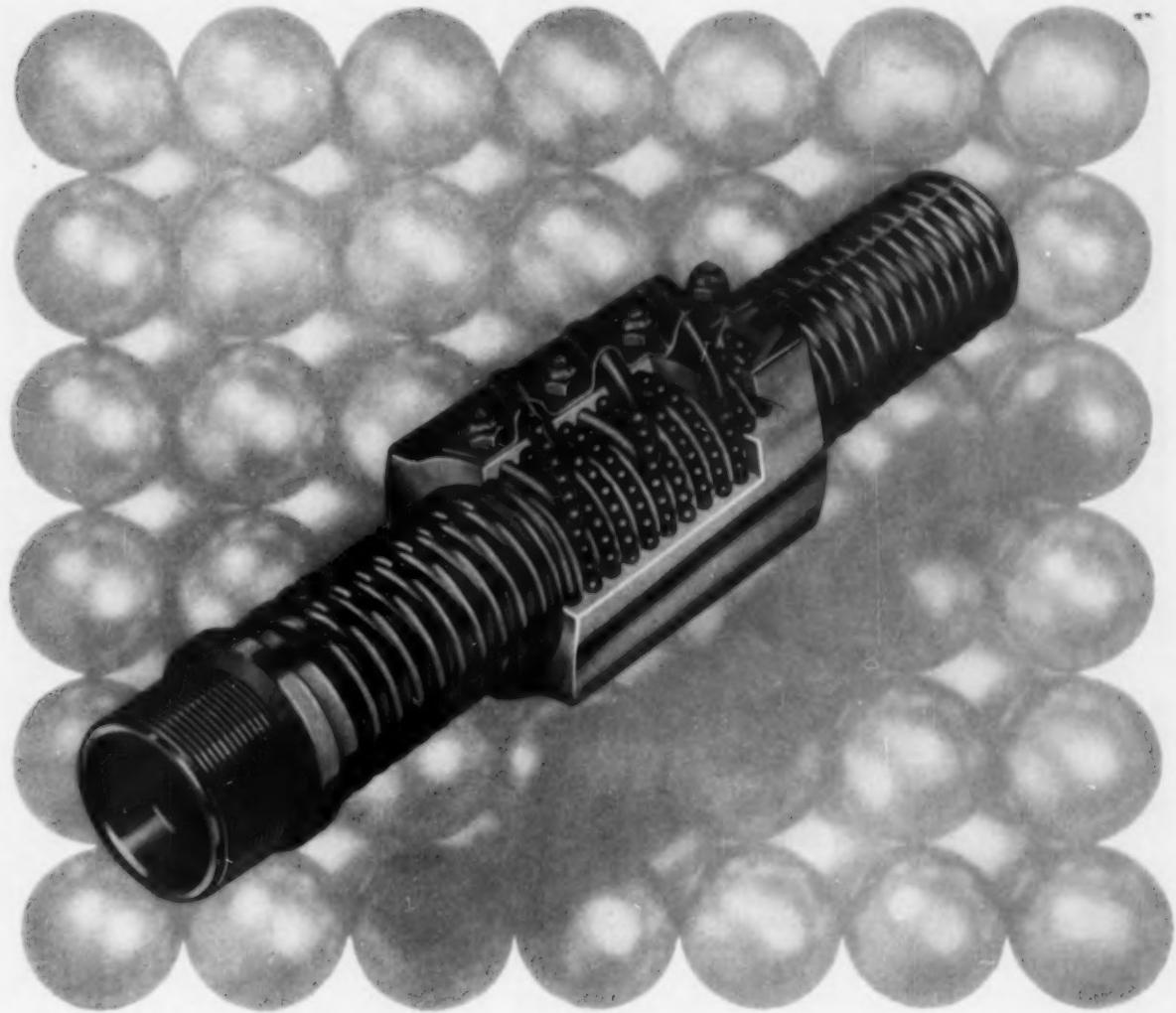
HOOKER ELECTROCHEMICAL COMPANY

405 Forty-seventh St., Niagara Falls, N. Y.

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**HOOKER
CHEMICALS**

-1090



how Vacuum Metals' FERROVAC boosts ball bearing screw life up to 400%...

Ball bearing screw assemblies, first used in automobile steering mechanisms, are now found in such critical applications as the actuation of landing gear and control surfaces of aircraft and guided missiles. And it was in tough jobs like these that the assemblies failed in fatigue. Then a leading manufacturer tried vacuum-melted FERROVAC® for the balls — and service life rose as much as 400% over the original life. Here's why ...

Vacuum melting improves fatigue properties — It literally sucks gaseous impurities — focal points for fatigue failure — from the molten metal. Vacuum-melted metals are cleaner, purer, tougher. And clean-

liness means an added bonus in fewer rejects.

Only Vacuum Metals gives you one-source service — Vacuum Metal's own large organization, and its affiliation with National Research Corporation and Crucible Steel Company of America, means a fully integrated service from melting and casting through mill rolling and nationwide distribution of finished mill products. And you can get not only small experimental lots, but now, thanks to our new 2500 lb. induction furnace — the nation's largest — you can also get large-scale continuous production quantities of vacuum-melted metals. If you have an application which these unique metals may improve, please write giving full details. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*



VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

Your Pyrometer



Check thermocouple circuits from your instrument panel during each heat. Save hundreds of hours inspecting and needlessly replacing thermocouples.

***THE RESTORER** detects and corrects thermocouple circuit failure during any heat treating or melting operation.

****THE LEAK-CHECKER** detects leaks in thermocouple protection tubes immersed in saltbath or other melting furnaces.

Write for
Catalog R-26
Electronics Division

THE Peerless-Electric® COMPANY
W. MARKET ST. • WARREN, OHIO
FANS • BLOWERS • MOTORS
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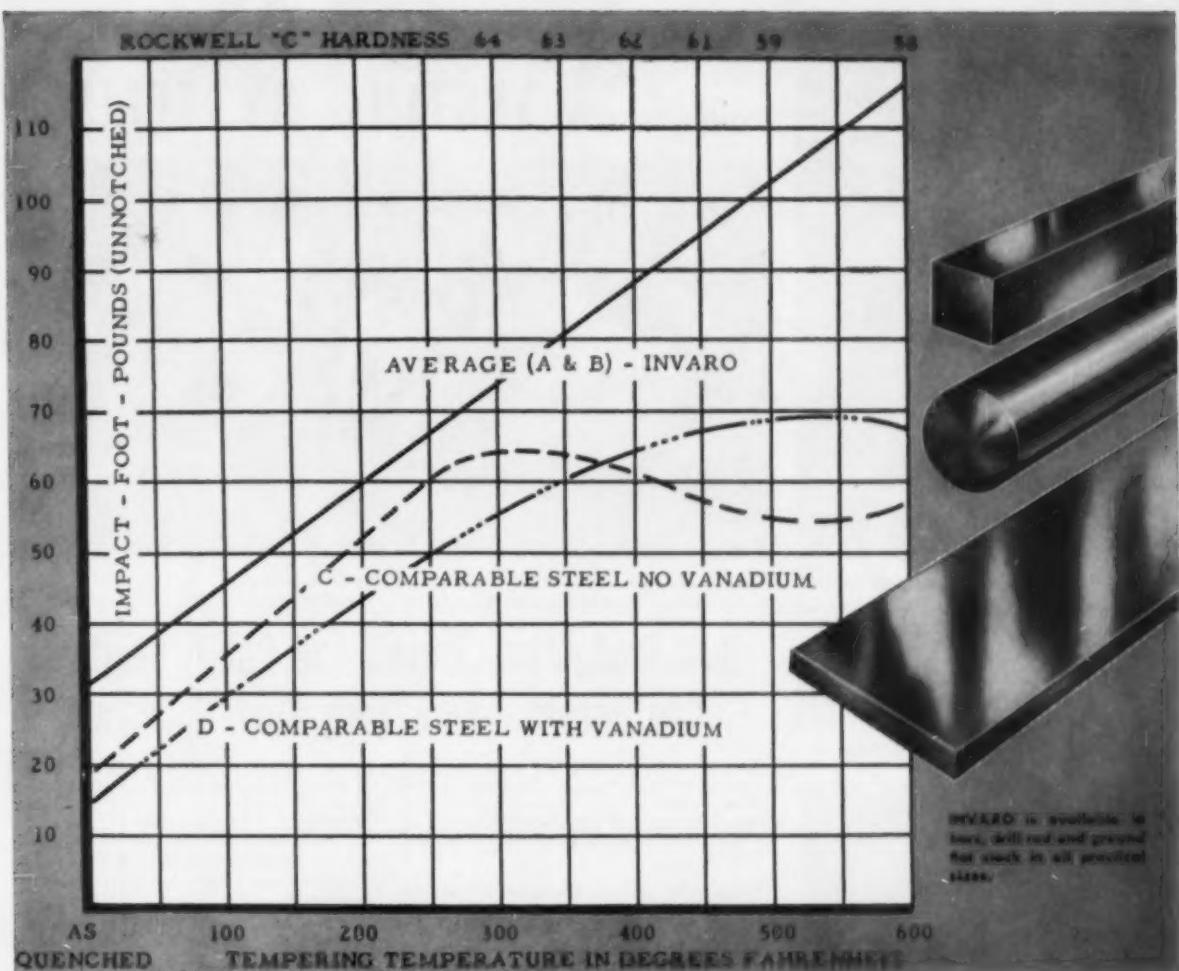
Since 1893

Visit Booth No. 706 at the Metal Show

THERMOCOUPLE CIRCUIT RESTORER CUTS INSPECTION and REPLACEMENT COSTS

Listed below are some purchasers of the Restorer* and Leak-Checker.**

BELL ANNEALING FURNACE	Allegheny Ludlum Steel Corp. Rome Strip Steel Co., Inc. Sharen Steel Corp.
BOX ANNEALING FURNACE	American Chain Division American Chain & Cable Co., Inc. Frazer & Jones Co.
CONTINUOUS ANNEALING FURNACE	Damascus Tube Co. Washington Steel Corp.
SALT BATH	Aircraft-Marine Products, Inc. The Electric Auto-Lite Co.
OTHERS	Battelle Memorial Institute Davison Chemical Company Div. of W. R. Grace & Co. Farrel-Birmingham Company, Inc. Ferriot Brothers, Inc. Johnson Bronze Co. U. S. Atomic Energy Commission



INVARO . . . IZOD-PROVED THE TOUGHEST of leading comparable oil-hardening tool and die steels

When the toughness of a tool and die steel is the critical factor of selection, Firth Sterling INVARO is the *toughest* of the tough! That's not just an opinion but a fact. Undeniable proof is established by the A.S.T.M. Izod Impact Test, results of which are graphically shown above, comparing steels both with and without vanadium.

INVARO shows a superior toughness in *all* ranges of temperature from a minimum advantage

of about 12% to as much as 100% greater! This marked superiority is the result of Firth Sterling's advanced metallurgical practices combined with 67 years of experience in the art of making specialty steels.

Yes, when you want *toughness* in your tools and dies, combined with uniformity, excellent hardening properties and safety in heat treating . . . specify INVARO.



Firth Sterling

—INC—

GENERAL OFFICES: 3113 FORBES ST., PITTSBURGH 30, PA.

MILLS: MCKEEPORT, TRAFFORD, DETROIT, HOUSTON

OFFICES AND WAREHOUSES: BIRMINGHAM CHICAGO* CLEVELAND DAYTON* HARTFORD* HOUSTON LOS ANGELES* NEW YORK PHILADELPHIA PITTSBURGH WASHINGTON WESTFIELD, N.J.

Chemical Analysis	All test samples were machined from half-inch annealed bar stock.								
	C	Si	Mn	S	P	W	V	Cr	
Invaro A	.88	.34	1.22	.010	.020	.49	.19	.50	
Invaro B	.94	.25	1.20	.014	.013	.53	.22	.49	
Comp. C	.90	.33	1.24	.011	.025	.50	—	.55	
Comp. D	.95	.34	1.27	.010	.020	.50	.21	.59	

PRODUCTS OF FIRTH STERLING METALLURGY	
High Speed Steels	Sintered Tungsten Carbides
Tire & Die Steels	Firth Heavy Metal
Stainless Specialties	Chromium Carbides
High Temperature Alloys	High Temperature Cermet
Zirconium	



SPOTCHECK PINPOINTS DANGER AREAS in heavy machinery and operating equipment. The Spotcheck dye penetrant inspection kit is excellent for testing during maintenance, or for intermittent spot testing for cracks and other surface defects. Kit contains all materials in easy-to-use pressurized spray cans plus a handy, lightweight carrying case.



NOW YOU CAN "SEE" DEFECTS in wires, rods and tubes of low conductivity metals such as aluminum, tungsten or uranium. The FW-200 Series unit sets up eddy-currents in the test materials. Using frequencies from 15KC to 2 MC, any cracks, splits or seams are detected and easy-to-read indications are shown on the TV-type picture tube. Diameter changes register separately. Adjustments can be made for a visible signal and automatic rejection of defective materials.



Write for complete details concerning any of the above case studies, or ask for our new booklet on "Lower Manufacturing Costs."

Case Studies: NONDESTRUCTIVE TESTING SYSTEMS



Type ZA-29 Zyglo unit is widely used and accepted for detecting surface defects in aluminum, magnesium, brass and titanium parts.

How Production, Payroll and Public Relations Can Benefit from "Early-Stage" Testing

The most for the least, that's what your customers want today. To help answer these demands and still show a profit, you can increase the output and quality of production without increasing costs and facilities.

By supplying process control and by maintaining consistent quality standards, Magnaflux nondestructive testing systems provide a quick, accurate, economical production tool. They can increase output and lower your operating costs. Magnaflux methods save money by keeping production at a dependable level.

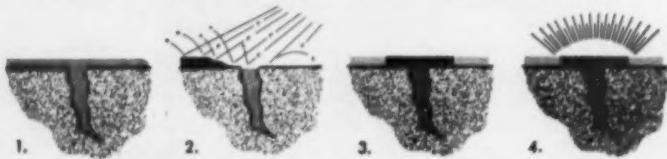
Magnaglow methods provide an "early-stage" test for the detection of surface defects in all magnetic and non-magnetic metals, ceramics, glass and other solid materials. "Early-stage" testing pinpoints improper proce-

dures and corrective steps can be taken to eliminate the manufacture of defective parts. Where serious defects do occur, parts can be rejected before further effort is wasted on additional processing. When defects are minor, repairs can be made to decrease scrap losses and upgrade salvage operations.

"Early-stage" testing with Magnaglow methods pays in many ways. It increases usable production output, it prevents unnecessary payroll costs on defective materials, it protects your reputation by insuring consistent quality, all of which means dollar savings to you!

Find out how low-cost Magnaflux non-destructive test methods can help protect your company's quality, pocketbook and name. Write, or call on a Magnaflux testing systems engineer today.

HOW ZYGLO FINDS CRACKS IN NON-MAGNETIC PARTS



1. A surface film of Zyglo penetrant is applied to parts by dipping, spraying or brushing. After this application, penetrant enters any surface opening, crack or pores, and excess penetrant is allowed to drain off. 2. Parts are then washed with a water spray, and permitted to dry.

3. Next, parts are dipped in a developing powder. This acts as a blotter, and draws the penetrant to the surface. 4. Look at the part under "black light". Any crack or surface defect will show up as a glowing fluorescent indication that is impossible to miss. Scratches will not be shown.

Take Your Inspection Problems to the House of Answers

MAGNAFLUX CORPORATION

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We welcome the opportunity of meeting with you
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There are several new developments with promising
applications which may be of interest to you.



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What Does Foote Mineral Company Mean to You, the Metallurgist?

Here are just a few Foote products used in the metallurgical industries. Your inquiry on any of them is invited.

PURE METALS

ELECTROMANGANESE®

Guaranteed 99.9+% pure manganese metal, Foote Electromanganese is an accepted raw material for the production of stainless steel and alloy metals. It is a key material in the increasingly more popular 200 series stainless steels.

New alloys, both ferrous and non-ferrous, are being developed around this versatile raw material. In addition, we offer two grades of Nitrelmang®, a nitrided manganese manufactured to close specifications. Nitrogen ranges are 4.25-4.75% and 5.5-6.0%.

LITHIUM METAL

As an alloy and deoxidizer for non-ferrous metals . . . as a metal scavenger and degasifier . . . these are among the important current uses for lithium metal. The metal typically analyzes 99.8% lithium.

Also available is lithium hydride. Other lithium metal derivatives can be obtained in experimental quantities.

DUCTILE ZIRCONIUM AND TITANIUM

High corrosion resistance to both acids and alkalies, low neutron absorption and remarkable affinity for gases are among the many unique qualities of zirconium.

This ductile metal is used in atomic reactors . . . as a "getter" in electronic tubes . . . as a non-corrosive metal in surgical specialties . . . and other applications. Zirconium is available in rods, sheets and wire.

Pure ductile titanium is available in bar form.



Foote MINERAL COMPANY

424 Eighteen West Chelten Building,
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RESEARCH LABORATORIES: Berwyn, Pa.

PLANTS: Exton, Pa.; Kings Mountain, N.C.;
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Since the days of the first coated welding electrodes, Foote has been the leading supplier of an ever growing list of quality raw materials used in coating formulations. The uniform particle size and chemical consistency of these Foote products are known and respected throughout the industry.

A special brochure covering these materials is available.

FOOTE TECHNICAL SERVICE

The experience and know how of Foote metallurgical sales and research engineers are available to you at all times. We invite you to draw upon them for technical assistance with any metallurgical problems within our broad field of interest.

FLUX & SLAG FORMING MATERIALS

Foote Mineral offers a wide variety of chemical, mineral and ore products used in the metallurgical field. All of these products are noted for their chemical consistency and uniform particle size.

Especially useful as fluxes for non-ferrous soldering, welding and brazing are the many lithium compounds which the company offers. The lithium ores hold promise in foundry applications and in solving slag problems.

SPECIAL PRODUCTS

RIMEX®

Developed by Foote, this specially formulated steel additive reduces the cost of producing rimmed steel while improving its quality. Rimex improves rimming action . . . minimizes ingot growth . . . and does not generate obnoxious fumes.

MANGANESE SULPHIDE

This fume-free ladle additive is used for producing high sulphur, free-machining steels with these advantages:

1. improved hot rolling behavior
2. fewer surface defects
3. fewer diversions
4. lower conditioning costs
5. low carbon content saves heat time

ZIRCONIUM METAL POWDER

For flash bulbs, pyrotechnics and ammunition, Foote offers ZMP in subsieve particle size ranges. This highly pyrophoric material is produced as "A" and "G" grade product.

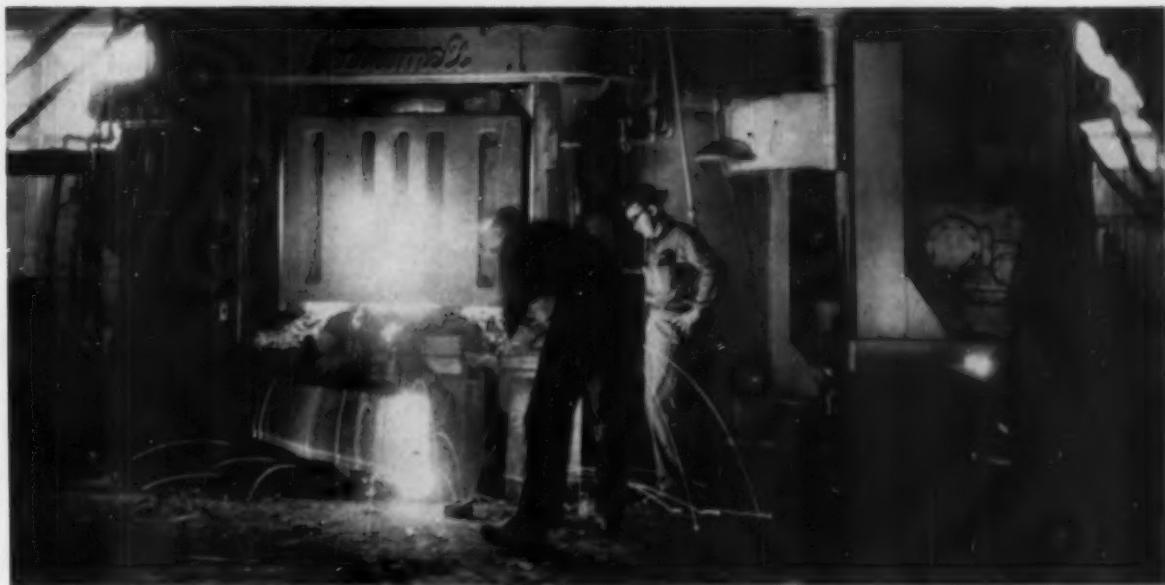
FOOTE MINERAL COMPANY

424 Eighteen W. Chelten Bldg., Phila. 44, Pa.
Please send me information about the following:

Name _____

Company _____

Address _____



Sample is poured into small mold. Test piece is sent to chemical laboratory through a pneumatic tube for complete analysis.

Strict Quality Control Required in Production of Stainless Steels for Critical Applications

Testing Process at Rotary Electric Steel Co. Continues through Each Step in Manufacture

Rotary Electric Steel at Detroit produces the high quality stainless and alloy steels needed for the automotive, aircraft, chemical, anti-friction bearing, and food-handling equipment industries, as well as for critical defense applications. Precise quality control and constant inspection at each processing step is basic in Rotary's production.

Raw Material

Testing starts even before the steel is in a molten state. The raw material for the electric furnace steels that Rotary produces is not ore, but steel scrap of the highest quality, to which is added various high-grade alloying elements. Quality control starts with the careful selection and grading of the scrap.

Melt Shop

Frequent samples are taken during the melting process and sent to the chemical laboratory for analysis. Several determinations are made on a direct-reading spectrometer

that enables a report on the chemical analysis to be made in minutes. Additional tests insure that the steel meets customer specifications. Before the steel is poured from the furnace the chemical laboratory approves the heat.

Processing

Tests are made at progressive stages of the processing. Chemical analyses are taken and samples submitted to the metallurgical department for additional tests as required, such as etch tests, tensile tests, magnaflux tests, and cleanliness ratings. Quality control at Rotary means that every order of steel shipped has had metallurgical approval as well as final physical inspection.

New Color Brochure

"How Steel Is Made at Rotary," an informative 4-color booklet, can be obtained by writing Rotary Electric Steel Co., Box 4606, Detroit 34, Michigan. Rotary has sales offices and agents in Detroit, Indianapolis, Newark, N.J., Cleveland, and Chicago.



Wissco Belts travel stamped aluminum plates for domestic refrigerator evaporators through multi-temperature-zone brazing furnace. This is another example of how . . .

FAMOUS NAMES ride on WISSCO BELTS

Reynolds Metals Company • Louisville, Ky.

Reynolds Metals Company, recognized as a leader in the aluminum industry, uses 80-20 alloy Wissco Rod Reinforced High Temperature Belts in this production-line operation at its Louisville plant.

The Wissco Belts are repeatedly subjected to elevated temperatures ranging from 1025° F. to 1190° F. and to the corrosive action of a salt flux. Wissco Belts have been used since the Reynolds plant was opened. They are standing up extremely well, and give economical service with minimum maintenance.

Wissco Alloy Processing Belts are the choice of many famous names in industry—leaders in their fields. You, too, will find Wissco the

most economical and efficient belt for high temperature jobs—for metals, ceramics, glass annealing and decorating.

For details, just write or call our nearest office:

THE COLORADO FUEL AND IRON CORPORATION

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WISSCO BELTS
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION

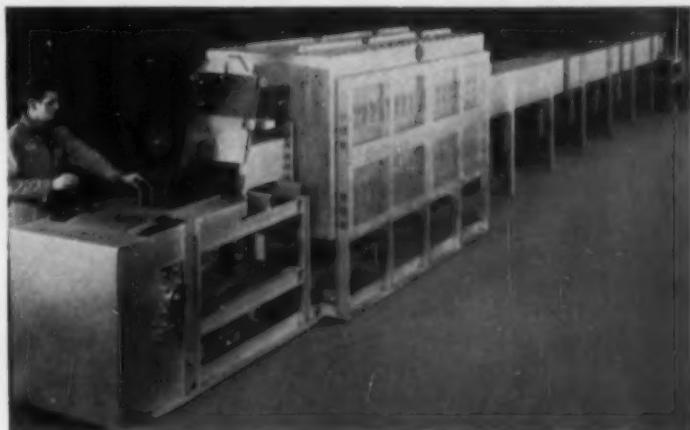


SELECTION GUIDE FOR BRAZING FURNACES

Check These Standard HARPER Controlled-Atmosphere Brazing Furnaces Against Your Requirements

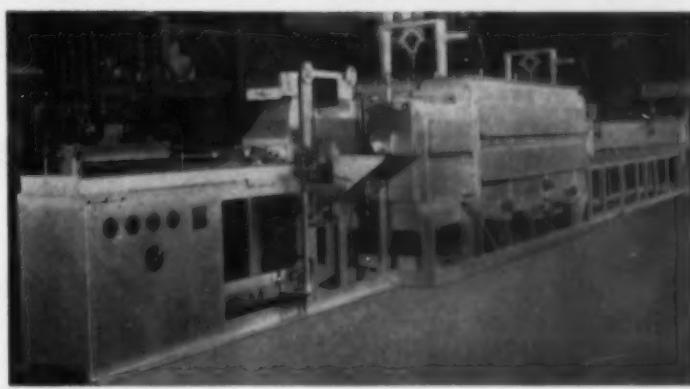
CONTINUOUS MESH BELT FURNACE

The perfect production furnace for brazing versatility. Provides adjustable speed automatic conveyance, precluding need for special fixtures, trays, etc. Ideal for silver or copper brazing of short runs on different shapes. Belt loading up to 10 pounds per square foot at 2100°F., larger loads permitted at lower temperatures. Belt widths to 24", charge heights to 12"; production capacities to 550 lbs/hr. Completely automatic operation available.



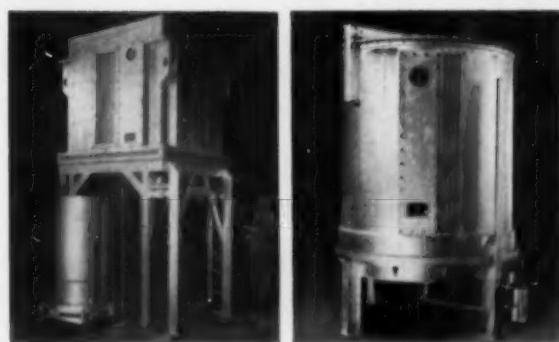
CONTINUOUS PUSHER FURNACE

The mechanical pusher furnace is designed for heavier loading (up to 100 pounds per square foot) and is therefore most suitable for large-production silver or copper brazing runs of heavier assemblies. Trays or special fixtures often used. Provides accurate atmosphere control. Pilot plant or small production units available for manual pusher operation. Standard hot zone sizes up to 18" x 9"; production capacities to 1000 lbs/hr.



ELEVATOR FURNACE

The best batch brazing furnace where maximum heat uniformity is important. Hearth is rolled away from furnace for easy loading, is repositioned under furnace, then raised into heating chamber. Ideal for large and/or heavy loads which must remain free of vibration during brazing. Adaptable to stainless steel brazing when muffle is used. Rapid cooling obtainable by removing work from furnace chamber. Available chamber sizes up to 150 cu. ft.



BELL FURNACE

The bell furnace is similar to the elevator except that the assemblies to be brazed may be stationary throughout the cycle. The load is placed on a fixed hearth and the furnace bell lowered over it. Generally available with nickel alloy heating elements for temperatures up to 2050°F. Special designs may incorporate silicon carbide for higher temperatures. Ideal for stainless work with muffle.

If you want more information on these or other Harper Furnaces, just check the coupon or visit Harper Booth 724 at the Cleveland Metal Show.



HARPER

ELECTRIC FURNACES

FOR

CONTINUOUS BRAZING, SINTERING, WIRE ANNEALING, BRIGHT ANNEALING,
ANNEALING, FORGING and RESEARCH

HARPER ELECTRIC FURNACE CORP.

40 RIVER ST., BUFFALO 2, N. Y.

Send data on Brazing Furnaces Checked:

- Mesh Belt Elevator Pusher Belt
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Title _____

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4,000 lbs. per hour in automated harden, quench and draw

Fuel costs are lowered 15 to 20% by use of continuous belt operating wholly within hardening furnace.

Manpower of two men is saved by automatic loading.

4,000 pounds per hour of automotive gears and clutch hubs are processed continuously.

Parts are hardened at 1650 degrees F., allowing one hour in the furnace. Then quenched in 1732 gallons of agitated oil at 130 degrees F. Drawing

temperature is 1200 degrees F., allowing 1/2 hour to heat and 1 1/2 hours at heat.

Loading is rated at 35 pounds per square foot of conveyor.

Entire line occupies a floor area—93'-9" long by 15'-0" wide by 13'-5 1/2" high.

**SEE US AT BOOTH 2561
NATIONAL METAL SHOW**

SAVE MONEY—LOAD AND PROCESS YOUR PARTS AUTOMATICALLY. WRITE FOR DETAILS

INDUSTRIAL HEATING EQUIPMENT CO.

Manufacturers of Industrial Furnaces and Oil Burners Since 1917

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NATIONAL METAL SHOW
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See for yourself the versatile engineering skill that is characteristic of these Heat and Corrosion Resistant Castings.

"PREFERRED BY INDUSTRY"

ALLOY ENGINEERING & CASTING COMPANY



ALLOY CASTING CO. (DIVISION)
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ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS



See the

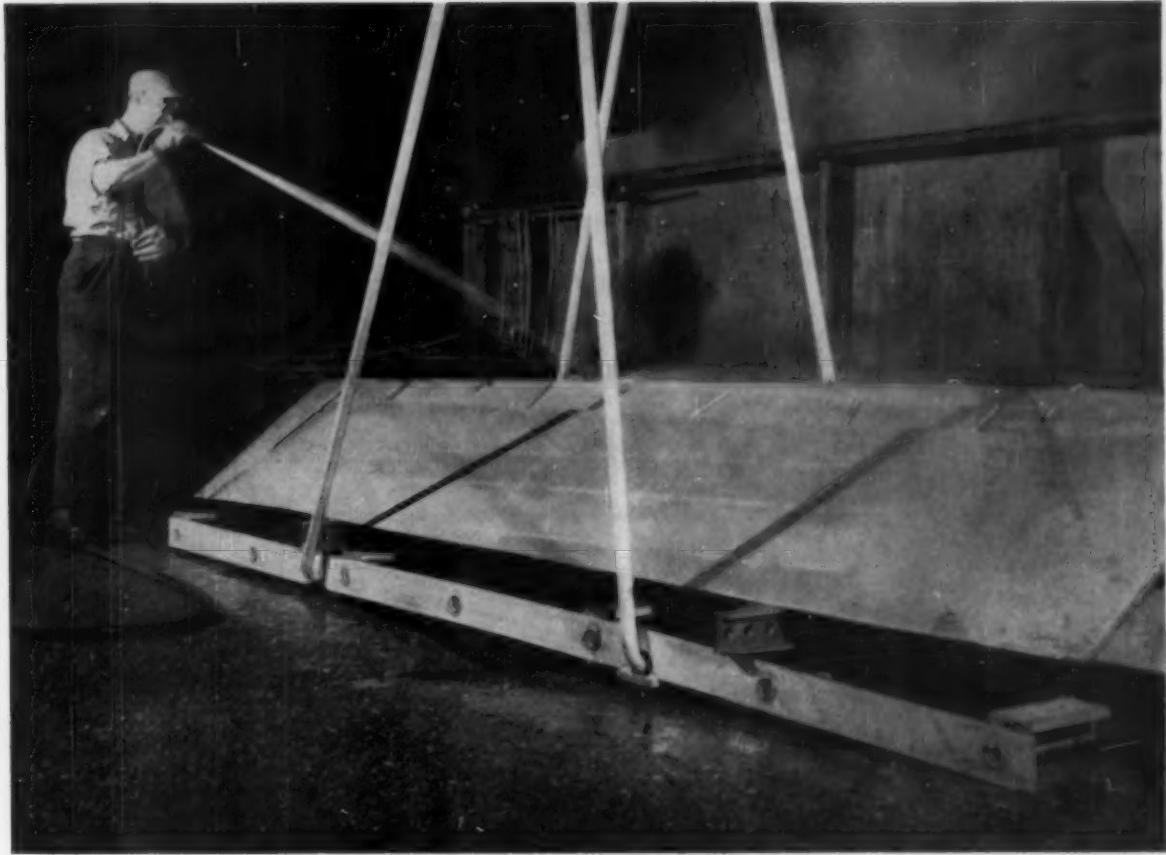
RANSBURG No. 2 Process

Electrostatic Spray

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Ransburg representatives will be on hand at all times to tell you about the money saving advantages which can be yours with the No. 2 Process.



With Du Pont Descaling Process...

Jessop Steel descales once and only once to get a Number 1 finish

Jessop Steel Company has had less than $\frac{1}{4}$ of 1% rejects due to unsatisfactory descaling over a ten-year period.

Fast, high-quality processing is of prime importance to this company, a specialty steel house in Washington, Pa. Here, stainless and clad steels are finished to exacting specifications...on short order. And that's why Jessop depends on Du Pont Sodium Hydride Descaling.

"When you've got a close deadline to beat, every operation has to be done right the *first time*. We can't afford to make false starts.

"Take the descaling operation, for instance. We know with the Du Pont Sodium Hydride Descaling Process that we can depend on obtaining the finish we want the first time. It is not necessary for a

piece to be processed several times to bring it up to the degrees of brightness we require. And, it's a costly and time-consuming operation to have work reprocessed."

This is typical of the results you can expect with the Du Pont Sodium Hydride Descaling Process in your operation. For complete details, call your Du Pont Representative or write: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Dept., Wilmington 98, Delaware.



BETTER THINGS FOR BETTER LIVING... THROUGH CHEMISTRY

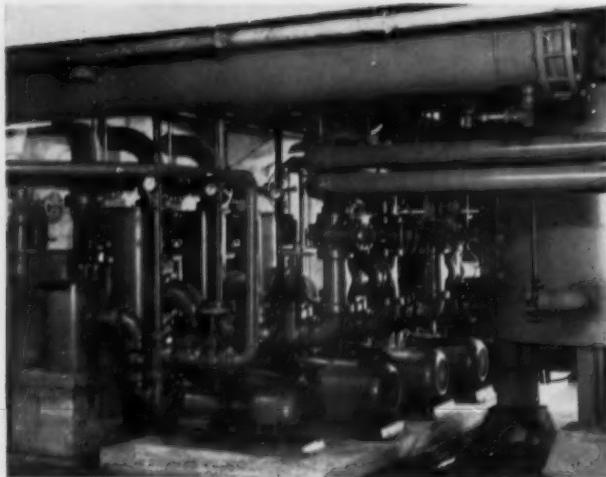
SODIUM HYDRIDE PROCESS FOR POSITIVE DESCALING

SEPTEMBER 1956

331



Controlled Quenching contributes to “flying box car” safety



Battery of B&G Pump for circulating quench oil.



B&G Quench Tank with B&G Circulating Pump.



Send for Catalog and
Simplified Selection
Manual



*REG. U.S.
PAT. OFF.

Controlled quenching with B&G equipment is an important step in heat treating landing gear struts for Fairchild "Flying Boxcars". It is one of the processes which assure an end product that will stand up under the high stresses and shocks which occur in landing a heavily loaded plane!

This installation is an outstanding example of excellent heat treating and quenching facilities. Most of the equipment is located in a basement with only the tops of the furnaces and quench tanks exposed above the steel plate floor.

The B&G Quench Tanks have a capacity of 1200 gallons. In the tanks, the oil is not only circulated rapidly and agitated but is changed once a minute by high capacity B&G pumps. Quench oil is drawn from storage tanks in the basement and is held at 135°-140°F. by live steam heat exchangers. With the rapid circulation and agitation of the oil, average loads are brought to quench oil temperature in about 15 seconds.

B&G Oil Quenching Systems are available either as component parts for assembly on the job, or as self-contained packages which combine Coolers, Motors, Pumps, Strainers and all controls into single, integrated units. Engineering service is always available.

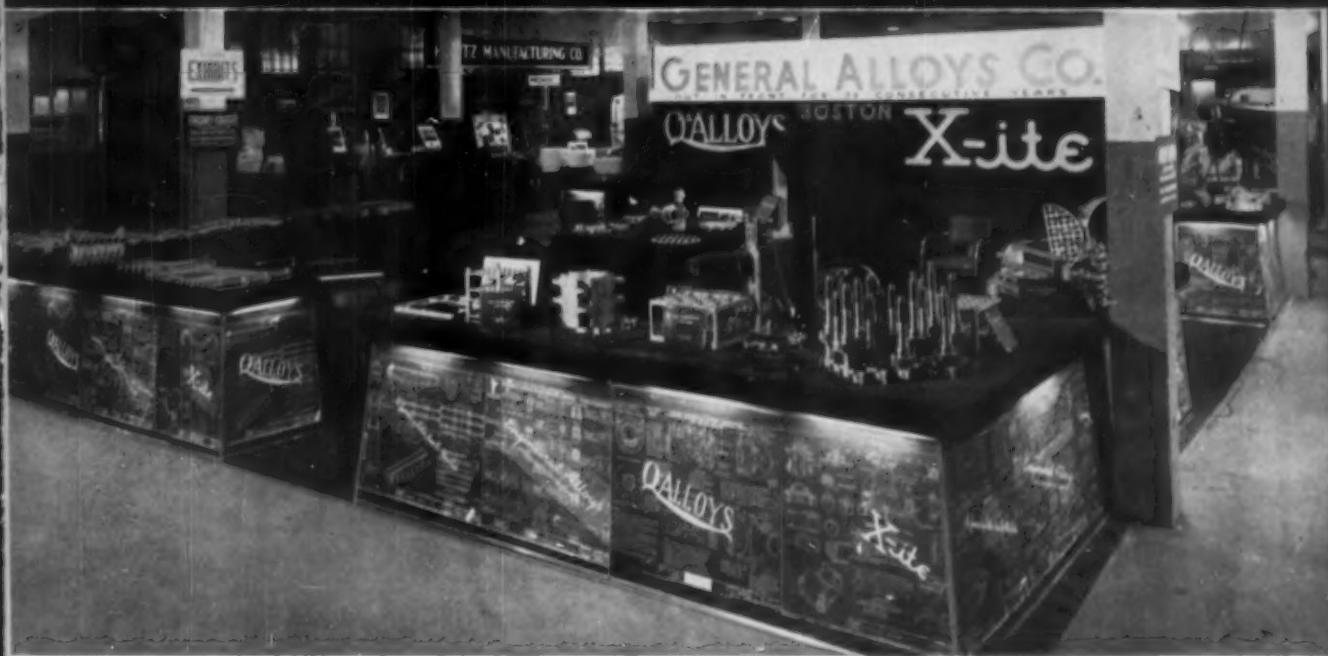
Hydro-Flo* OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. EM-16, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, W. Toronto

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY



Pick two numbers from one to ten and you can get a
three and an eight . . .

YES, **38** CONSECUTIVE YEARS
AS USUAL, AT THE MAIN ENTRANCE OF THE
NATIONAL METAL EXPOSITION

THERE IS NO SUBSTITUTE FOR EXPERIENCE

General Alloys Company is an engineering organization with 38 years experience in the design and manufacture of heat resistant and stainless steel castings. The design of high temperature tooling is our specialty. Consult our specially trained sales engineers in Booth No. 351 at the National Metal Show concerning your alloy problems.

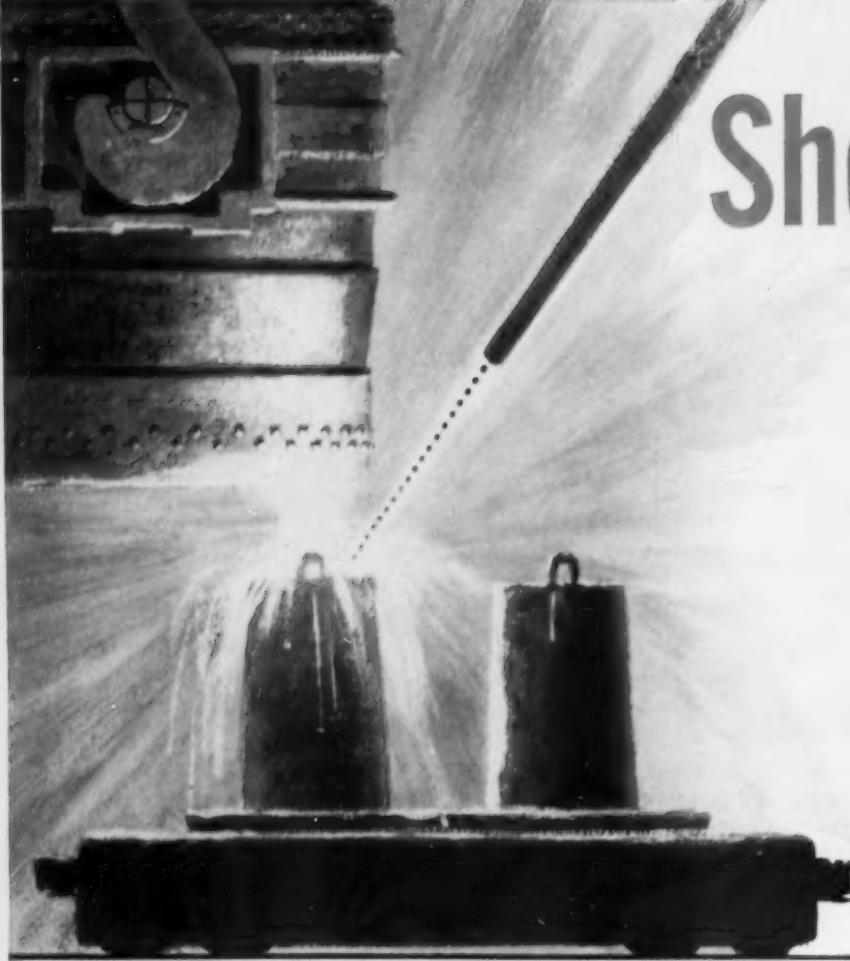
GENERAL ALLOYS COMPANY, BOSTON, MASS.

"**OLDEST AND LARGEST EXCLUSIVE MFRS. OF HEAT & CORROSION RESISTANT CASTINGS**"

Q'ALLOYS

THE QUALITY NAMES IN ALLOY
FOR HEAT CORROSION ABRASION

X-ite



Shooting lead into steel!

Lead, strange as it may seem, imparts certain desirable machining properties to steel. Leaded steel has been found to be particularly suitable for parts going into business machines, textile machinery, hydraulic fittings, and other equipment where extensive low cost machining is required. Leaded steel in appreciable tonnages is now a part of our big steel output.

At first, the problem of introducing lead into steel and of dispersing it satisfactorily seemed insoluble. Great differences in melting points

and in specific gravities tended strongly toward segregation and gas pockets when steel men tried to blend molten steel and molten lead.

Carefully graded, fine lead shot of high purity provided the answer to this production problem. By a carefully controlled process these shot are 'fired' into the stream of molten steel as it is teemed into the ingot mold.

Leaded steels provide added evidence of the usefulness and versatility of the basic metal — LEAD.

ST. JOSEPH LEAD COMPANY
The Largest Producer of Lead in the United States
250 PARK AVENUE, NEW YORK 17, NEW YORK



METALLURGISTS...



Help develop the world's first nuclear powered fleet

Nuclear power offers tremendous advantage for naval vessels. From the fuel standpoint, cruising ranges are virtually unlimited—even at new high speeds. No refueling facilities will be required to replenish nuclear propulsion fuel. Therefore, the physical design of the fleet can be streamlined for greater efficiency and safety.

At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: the development of fuel alloys; the development of clad alloys; fuel element development; and technical control of fuel elements and fuel and clad alloys. At Bettis you will have a choice of working in either Basic or Applied Metallurgy. You may prefer to conduct basic research in areas like these: 1) Solid phase transformation, 2) Corrosion kinetics

and mechanisms, 3) Effect of irradiation on metals, 4) Internal friction studies, 5) Study of equilibrium diagrams.

To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

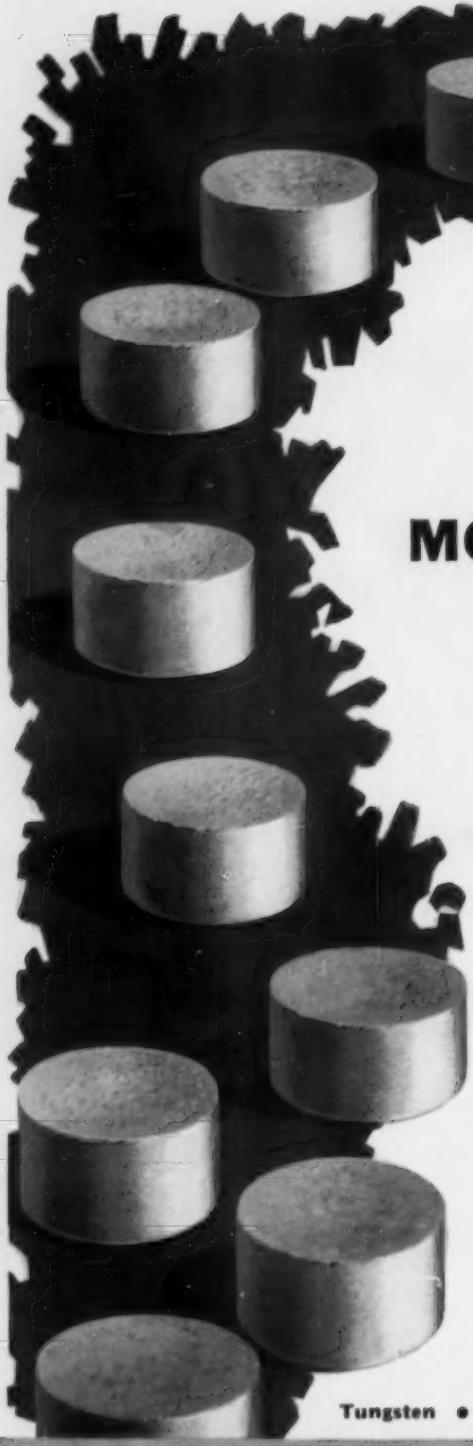
What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A71, P.O. Box 1468, Pittsburgh 30 Pa.



BETTIS PLANT Westinghouse



NEW

from Sylvania
High purity

MOLYBDENUM PELLETS

for vacuum melting

If you are a producer of high creep strength alloys or high-temperature super alloys, you will find that Sylvania's molybdenum pellets have the characteristics you need to meet exacting specifications.

Sylvania's molybdenum pellets are controlled to a 99.5 per cent minimum purity, with a typical purity of 99.85 per cent. Gas content is kept low by maintaining a maximum density. Pellets (1" in diameter by $\frac{1}{2}$ " thick) make it easy to calculate additions and charge to the melt.

Pelletized molybdenum offers obvious advantages over scrap in alloy production. Unit costs are constant. Reproducibility of results is assured. High purity and low gas content make it easier and less costly to meet rigid production specifications.

Also available from Sylvania is high-purity tungsten, in sintered ingot form, suitable for vacuum melt alloying.

A Sylvania sales engineer will be glad to discuss your molybdenum and tungsten needs with you. Write for technical specifications and quotations.

SYLVANIA ELECTRIC PRODUCTS INC.
Tungsten and Chemical Division
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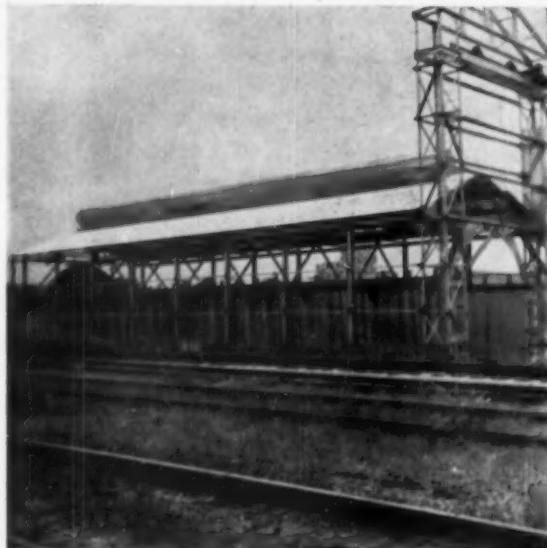
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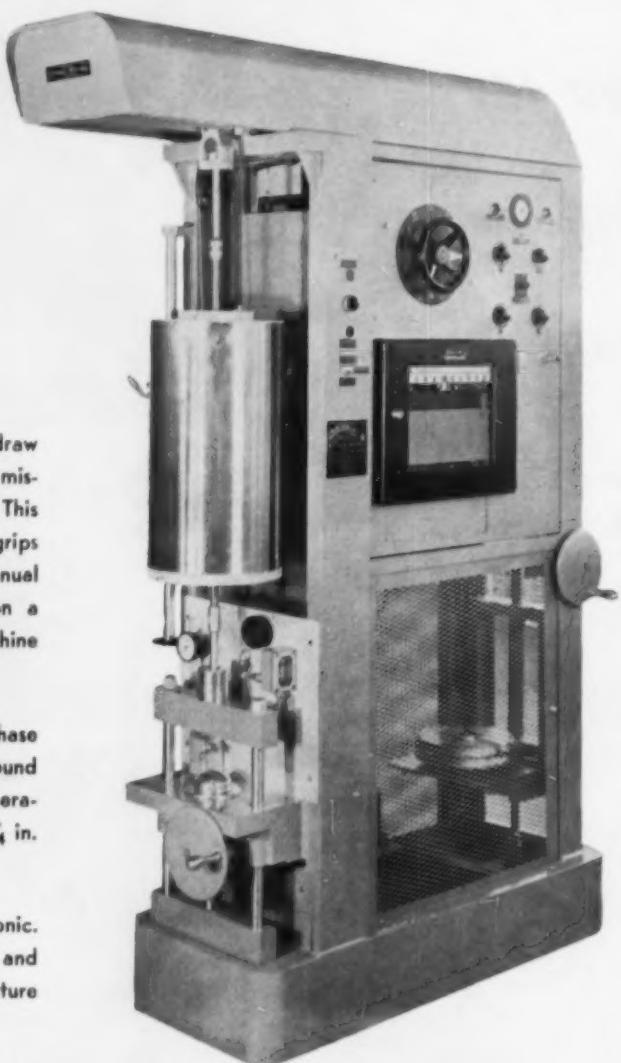
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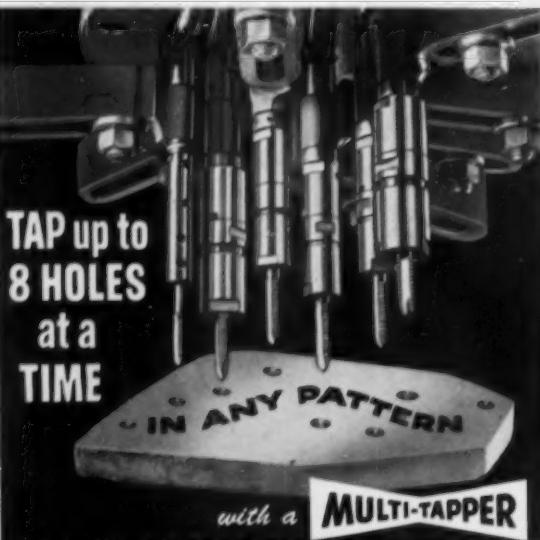
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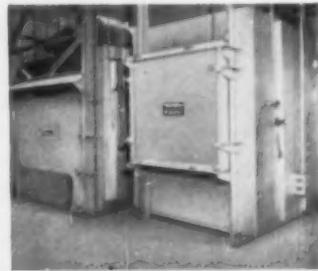


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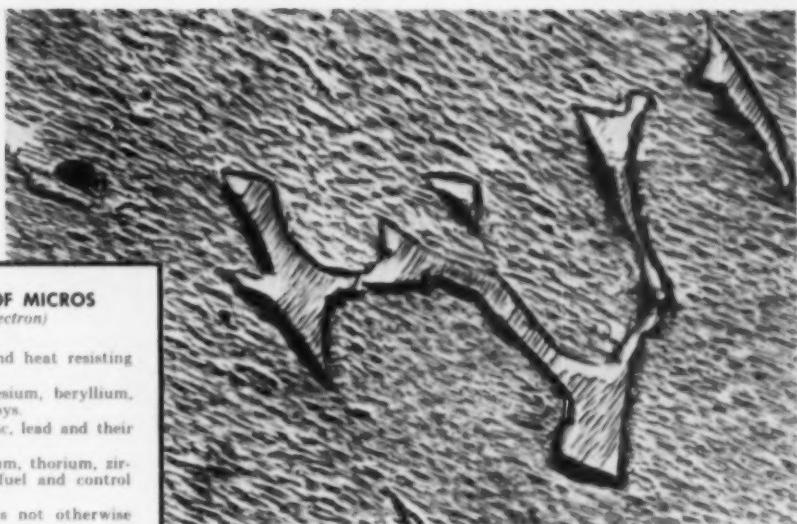
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- Class 6. Metals and alloys not otherwise classified.
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- Class 8. Welds and other joining methods.
- Class 9. Surface coatings and surface phenomena.
- Class 10. Results by unconventional techniques (other than electron micrographs).
- Class 11. Slags, inclusions, refractories, cermets and aggregates.
- Class 12. Color prints in any of the above classes (no transparencies accepted)

RULES FOR ENTRANTS

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints should be mounted on stiff cardboard; maximum dimensions 14 by 18 in. (35 by 45 cm.). Heavy, solid frames are unacceptable. Entries should carry a label on the face of the mount giving:

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Material, etchant, magnification
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Entrants living outside the U. S. A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection".

Exhibits must be delivered before Oct. 1, 1956, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

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Entries are invited in the 11th ASM Metallographic Exhibit, to be held at the National Metal Exposition in Cleveland, Oct. 6 through 12, 1956.

AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of \$100, will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters in Cleveland.

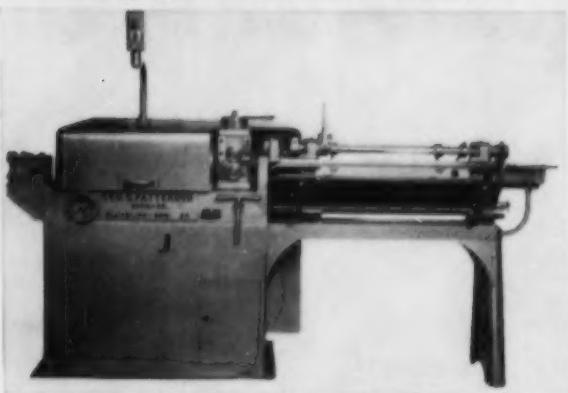
All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1957 if so desired.

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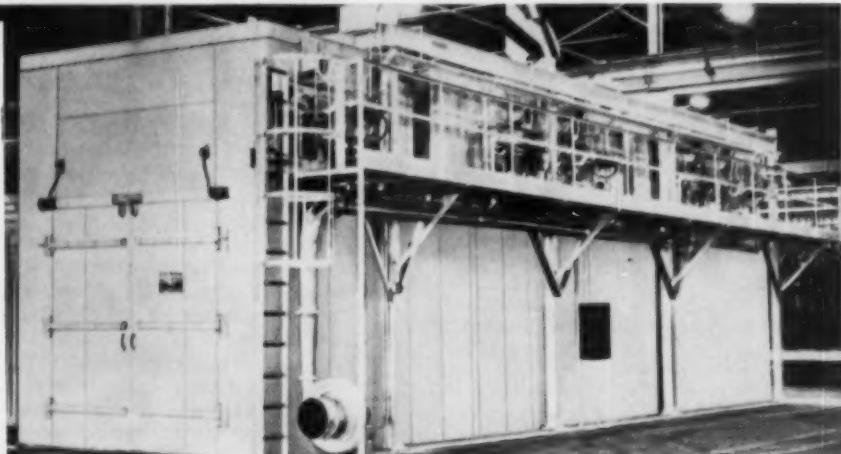
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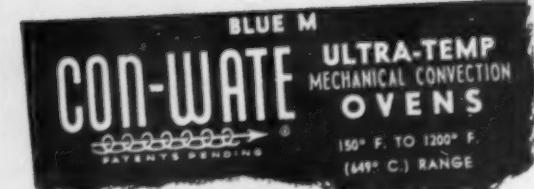
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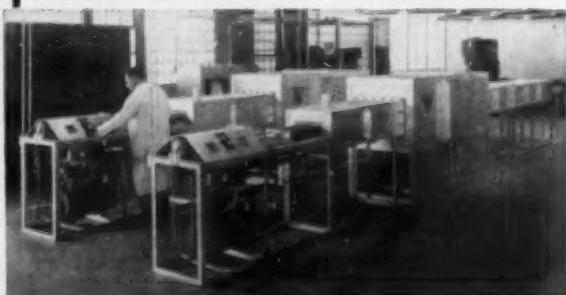
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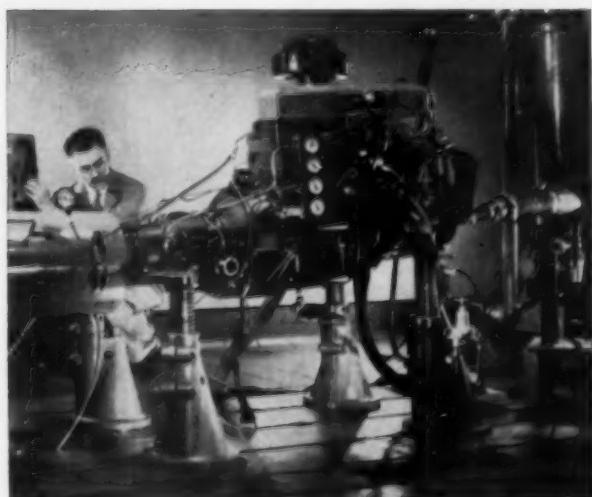
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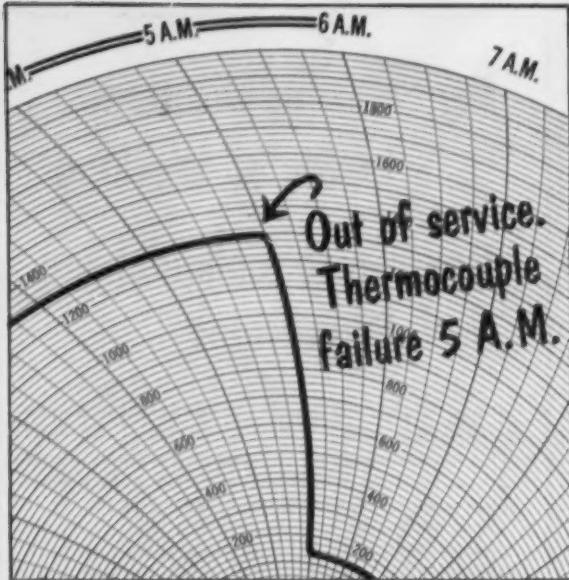
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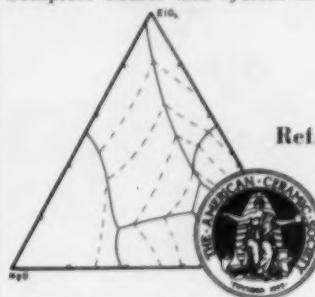


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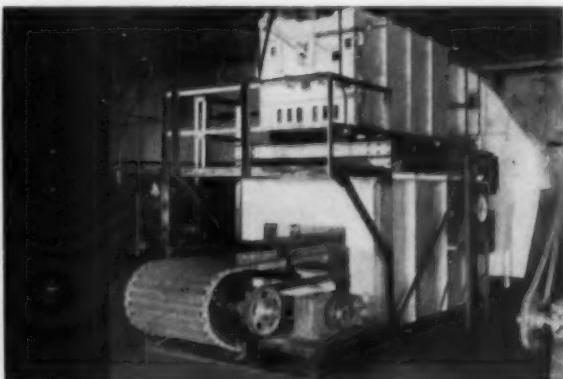
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• Index to Advertisers •

Acheson Colloids Co.	59	Crucible Steel Co. of America	147, 177, 193, 233, 289	Industrial Heating Equipment Co.	164, 328
Air Reduction Sales Co., Inc.	274	Curtiss-Wright Corp.	12, 315	International Nickel Co.	364, 313
Ajax Electric Co.	241	Cyril-Bath Co.	8-9	Illinois Testing Laboratories, Inc.	265
Ajax Electrothermic Corp.	191	Darwin & Milner, Inc.	180	Jarrell-Ash Co.	175
Ajax Engineering Corp.	229	Detrex Chemical Industries, Inc.	178	Jeffif Mfg. Corp., C. O.	164
Ajax Manufacturing Co.	245	Detroit Electric Furnace Div.	238	Johns-Manville	145, 304
Aldridge Industrial Oils, Inc.	163	Kahlman Electric Co.	28	Jones & Laughlin Steel Corp.	179, 297
Allegheny Ludlum Steel Corp.	.96C	Detroit Flame Hardening Co.	238	Kennametal, Inc.	216
Allied Research Products, Inc.	140	Detroit Testing Machine Co.	29	Kent Cliff Laboratories Div.	
Alloy Engineering & Casting Co.	329	Douston Division, Henry H. K. Porter Company, Inc.	159	Torsion Balance Co.	165
Alloy Metal Wire Div.		Dixon Corp.	167	King Tester Corp.	27
H. K. Porter Company, Inc.	184	Dow Chemical Co.	256-257	Kinney Mfg. Div. of N.Y. Air Brake Co.	283
Alpha Molykote Corp.	166	Dow Furnaces Co.	148	Kox Machine Co.	276
Alspach Engineering Corp.	163	Driver Harris Co.	199	L & L Mfg. Co.	165
Alster Company	49	Drop Forging Association	213	Lake Shore, Inc.	345
American Brass Co.	63	Du-Lite Chemical Corp.	163	Lakeside Steel Improvement Co.	381
American Ceramic Society	346	duPont de Nemours & Co., Inc.	331	Latreco Steel Co.	13
American Chemical Paint Co.	300B	Duraloy Co.	194	Leeds & Northrup Co.	260-261, 280, 344
American Gas & Electric Service Corp.	232	Eastman Kodak Co.	202-203	Lemnos Products, Inc.	36
American Gas Association	282	Eklips Fuel Engineering Co.	285	Lewis Machine Company	6-7
American Gas Furnace Co.	155	Electric Furnace Co.	Inside Back Cover	Lindberg Engineering Co.	
American Machine & Metals, Inc.	18	Electro Alloys Div.		Heat Treating Division	226-227
American Optical Co.	172	American Brake Shoe Co.	2	Linde Air Products Co., Unit of Union Carbide & Carbon Corp.	309
American Platinum Works	38	American Metallurgical Co., Unit of Union Carbide & Carbon Corp.	134-135	Lotus Engineering Co.	255
American Society for Metals	264, 287, 339	Elgin National Watch Co.	240	Los Alamos Scientific Laboratory of the University of California	169
Amperex Metal, Inc.	185	Engineered Precision Casting Co.	168	Lucifer Furnaces, Inc.	165
Antara Chemicals	34	Eustone, Inc.	306	Lumalite Division	32D
Applied Research Labs	188	Eveon Camera Corp.	263		
Arcrewd Manufacturing Co.	338	Erie Products, Inc.	166		
Armstrong-Blum Mfg. Co.	183	Erie Foundry Co.	14-15		
Arwood Precision Casting Corp.	35	Fahrray Co.	275		
Ashworth Brothers, Inc.	252	Federated Metals, Div. of American Smelting & Refining Co.	240		
Assembly Products, Inc.	340	Fenn Manufacturing Co.	33		
Association of Iron & Steel Engineers	151	Finkl & Sons Co., A.	17		
Babcock & Wilcox Refractories Division	48	Firth Sterling, Inc.	321		
Babcock & Wilcox, Tubular Products Div.	24	Flick-Reedy Corp.	20, 21		
Baird Associates	184B	Film & Dreifuss Engineering Co.	387		
Baker & Co., Inc., Engelhard Industries	254	Forte Mineral Co.	324		
Baldwin-Lima-Hamilton	54-55	Gas Machinery Co.	258		
Barber-Colman Co.	165	General Alloys Co.	333		
Wheeler Instruments Div.	45	General Aniline & Film Corp.			
Bausch & Lomb Optical Co.	96D, 158	Anseco Division	290		
Bede Products Corporation	234	General Electric Co.	266-267		
Bell & Gossett Co.	322	Globe Steel Abrasive Co.	142		
Bendix Aviation Corp.	312	Gordon Co., Claud S.	244		
Bethlehem Steel Co.	207, 307	Grati Colloids Corp.	345		
Blaw-Knox Co.	197	Great Lakes Carbon Corp.	195		
Blue M Electric Co.	344	Great Lakes Steel Corp.	298		
Branson Ultrasonic Corp.	162	Grinn Industries, Inc.	167		
Bristol Co.	278, 346	Gulf Oil Corp.	56-57		
Brock & Perkins, Inc.	25	Handy & Harmon	213		
Brush Beryllium Co.	264	Hanson-Van Winkle-Munning	300		
Budd Company, The	286	Harnischfeger Corp.	149		
Buehler, Ltd.	181	Harper Electric Furnace Corp.	327		
Bunting Brass & Bronze Co.	296	Harshey Scientific Div.			
Cambridge Wire Cloth Co.	146	Harshaw Chemical Co.	219		
Carborundum Co.	179	Hayes Inc., C. I.	310		
Carl Mayer Corp.	346	Haynes Stellite Co., Unit of Union Carbide & Carbon Corp.	297		
Carlson Co., G. O.	170-171	Heath Corp.	243		
Carpenter Steel Co., The	511	Hevi Duty Electric Co.	210, 211		
Central Foundry Division General Motors Corporation	40	High Vacuum Equipment Corp.	29		
Chase Brass & Copper Co.	217	High Voltage Engineering Corp.	156		
Chemical Corp.	25	Hill Arms Co.	182		
Cincinnati Milling Machine Co.	28	Holcroft & Co.	48A		
Cincinnati Sub-Zero Products Co.	220	Holden Co., A. F.	164		
Ciro Equipment Co.	162	Hones, Inc., Chas. A.	92		
Cities Service Oil Co.	16	Hooke Electrochemical Co.	318		
Clark Instrument Co.	236	Hoover Co.	166		
Cleveland Electric Illuminating Co.	343	Hoskins Mfg. Co.	174		
Climax Molybdenum Corp.	61, 157, 205	Houghton & Co., E. F.	325		
Cold Metal Products Co.	48B	HPL Manufacturing Co.	39		
Colorado Fuel & Iron Corp., The	326				
Commander Mfg. Co.	340				
Continental Industrial Engineers, Inc.	154				
Cooper Alloy Corp.	314				
Copperweld Steel Co.	Back Cover				
Copperweld Steel Co., Ohio Seamless Tube Div.	221				

National Carbon Co., Unit of
Union Carbide & Carbon Corp.

National Research Corp.

National Spectrographic Sales Corp.

National Standard Co.

Newage International, Inc.

Nitrogen Division

Allied Chemical & Dye Corp.

Norfolk & Western Railway

North American Mfg. Co.

Norton Co.

Oakite Products, Inc.

Ohio Crankshaft Co.

Ohio Seamless Tube Division of
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Ohio Steel Foundry.

(Continued on page 348)

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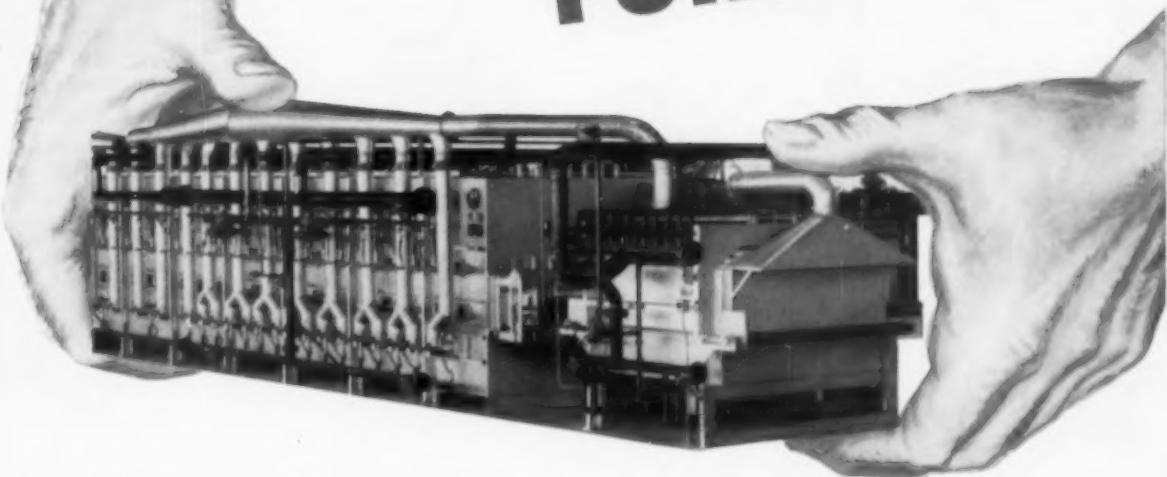
Pacific Scientific Co.	277
Pangborn Corp.	46
Park Chemical Co.	259
Patterson Machine Co., Gen. C.	342
Pearless Electric Co.	320
Penn Precision Products, Inc.	41
Permy Equipment Co.	344
Pickards Mather & Co.	247
Picker X-Ray Corp.	69
Pressed Steel Co.	43
Proctor & Gamble Co.	271
Production Specialties, Inc.	161, 162
Pyrometer Instrument Co.	242
Radio Corp. of America	224
Ransburg Electro-Coating Corp.	330
Raybestos-Manhattan, Inc.	
Manhattan Rubber Div.	162
Revere Copper & Brass, Inc.	138-139
Rigidized Metals Corp.	167
Rockwell Co., W. S.	236
Roiled Alloys, Inc.	254
Roll Formed Products Co.	167
Relock, Inc.	150
Rotary Electric Steel Co.	325
Roto-Finish Company	190
Ryerson & Son, Inc., Jos. T.	64
St. Joseph Lead Co.	334
Salem-Brosius, Inc.	200A
Sandvik Steel, Inc.	189
Saunders & Co., Alexander	242
Scherr Co., Inc., George	345
Seaville Mfg. Co.	42
Selas Corp. of America	294
Sel-Rex Precious Metals, Inc.	161
Sentry Co.	214
Seymour Mfg. Co.	30
Sharon Steel Corp.	153
Shieldalloy Corp.	246
Shore Instrument & Mfg. Co., Inc.	167
Sieburg Industries	167
Sinclair Refining Co.	235
Sinton Corp. of America	215
Solventol Chemical Products, Inc.	5
Spencer Turbine Co.	201
Sperry Products, Inc.	288
Stanat Mfg. Co., Inc.	218
Standard Steel Treating Co.	343
Stanwood Corp.	163
Star Stainless Screw Co.	168
Steel City Testing Machines, Inc.	196
Stokes Machine Co.	336-337
Stoody Company	244
Sunbeam Corp.	253
Sun Oil Co.	22, 30-31
Superior Tube Co.	141
Surface Combustion Corp., Inside Front Cover	
Swift Industrial Chemical Co.	164
Sylvania Electric Products, Inc.	336
Technic, Inc.	161
Thermo Electric Co., Inc.	32
Tickle Engineering Works, Inc., Arthur	291
Timken Roller Bearing Co.	209
Titanium Alloy Mfg. Div.	
National Lead Co.	323
Titan Metal Mfg. Co.	184A
Torsion Balance Co.	32
Tru-Seal Division, Flick-Reedy Corp.	21
Ture Products, Inc.	137
Union Carbide & Carbon Corp.	164-H, 184-185, 297, 309
United Scientific Company	308
United States Steel Corp.	32A-D
USS Alloy Steel	32A
USS Forgings	32B-C
U. S. Industrial Chemicals Co.	200
United Wire & Supply Corp.	176
Unit Process Assemblies, Inc.	167
Upton Electric Furnaces Co.	163
Utica Drop Forge & Tool Corp.	284
Vacuum Metals, Inc.	319
Vanadium Corp.	248-249
Vulcan Crucible Tool Steel, Div. of H. K. Porter Company, Inc.	228
Waukesha Engineering Co.	342
Waukesha Foundry Co.	239
Westinghouse Electric Corp.	
206, 230-251, 292, 301, 335	
West Instrument Corp.	186
Weston Electrical Instrument Corp.	10-11
Wheeler Instruments Div.	
Barber-Colman Co.	45
White Metal Rolling & Stamping Corp.	168
Wickwire Spence Steel Div., of Colorado Fuel & Iron Corp.	326
Wilson Mechanical Instruments Div., American Chain & Cable	144
Wiremen Mfg. Co.	164
Wyckoff Steel Co.	208
Wyman-Gordon Co.	268
Yoder Co.	58
Young Bros.	340
Youngstown Sheet & Tube Co.	62
Youngstown Welding & Engineering Co.	162, 316
Ziv Steel & Wire Company	352

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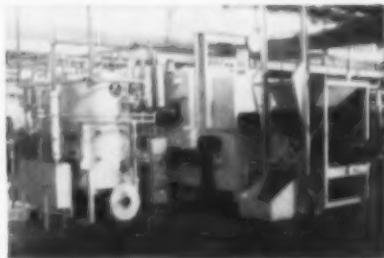


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